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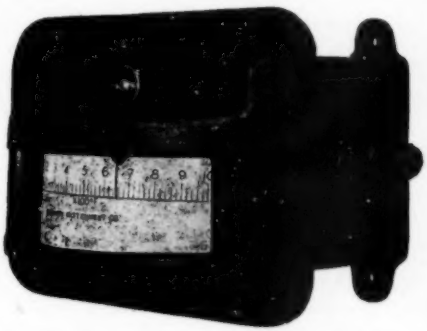

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NEW PATHS IN CRYSTAL PHYSICS

THE vast majority of actual solids are crystalline in their ultimate structure. Hence arises the theoretical and practical importance of the subject of crystal physics, and the need for a correct understanding of its fundamental principles. The outstanding feature of the crystalline state of matter is the three-dimensional periodicity of the structure of a crystal, which consists of a great number of similar, similarly situated and oriented groups of atoms, thereby securing for it the fundamental property of physical homogeneity. The size of the individual units or lattice cells of the structure is, in general, of extreme smallness in comparison with the overall dimensions of a macroscopic crystal. It follows as a consequence that the characteristic physical properties of a crystal are determined by its lattice structure and that the form or extension of its exterior boundary is a matter of complete indifference, so long as the crystal is of macroscopic dimensions. These considerations are so little controversial that the need for stressing them here requires explanation. The mathematical physicists of the nineteenth century were so largely concerned with the so-called "boundary value problems" that the tendency has grown up of regarding every physical question needing theoretical treatment as a "boundary value problem" and trying to set up "boundary conditions" for its solution irrespective of whether such considerations are relevant to the problem or not. The subject of crystal physics has in particular suffered from this tradition inherited from an earlier epoch, so much so that theories resting on it continue to be believed in despite their being in total contradiction with the experimental facts. It is proposed in this report to consider a fundamental topic in crystal physics in which such a situation exists, *viz.*, the nature of the vibration spectrum of a crystal lattice. A similar situation has also arisen in a related subject of scarcely less importance, namely, the electronic energy levels of a crystal lattice, but this will be dealt with on a later occasion.

The Atomic Vibration Spectrum

The frequencies of vibration of the atoms in a crystal about their positions of equilibrium in the space lattice lie in the infra-red and may be made accessible to study by various spectroscopic methods. It is evident that the frequency spectrum of the atomic vibrations thus made observable is a characteristic physical property of the crystal. The problem of ascertaining it is in many respects similar to that of finding the vibration spectrum of a polyatomic molecule and can be handled by very similar methods. For this purpose, we consider the equations of motion of the atoms contained in the unit cell of the crystal lattice. If there are p atoms in the unit cell, there would be $3p$ equations of motion to be solved. The equations would contain the displacements of the atoms included in the unit cell under consideration, as also the displacements of the atoms in the surrounding cells which influence the motion of the former. The equations of motion of the atoms included in these other cells must also be simultaneously satisfied. The relations which must subsist between the various atomic displacements for this to be possible are indicated by the following considerations. Firstly, we remark that as a consequence of the translational symmetry of the crystal, a normal mode of vibration must remain as such when the crystal lattice is given a unit displacement along any one of the three axes of the space lattice. Secondly, we recall the fundamental property of a normal mode that all the particles of the system vibrate with the same frequency and pass simultaneously through their positions of equilibrium, so that the phases of vibration are all either the same or opposite. Combining these two propositions, it follows that the amplitudes of vibration of equivalent atoms remain the same, while the phases either all remain the same or else are all reversed as the result of the unit translation. In other words, in a normal mode, equivalent atoms have the same amplitudes, and either all the same phase or alternately opposite phases of vibration in successive cells along each axis of the lattice. Thus two alternative possibilities arise in respect of each of the three axes, and since they are independent, we have $2 \times 2 \times 2$ or 8 distinct possibilities to be considered. For each of these 8 possibilities we have $3p$ equations of motion involving only $3p$ unknown co-ordinates, and hence capable of being completely solved. Thus in all we have $8 \times 3p$ or $24p$ solutions, which after excluding the three simple translations of the unit cells give us $(24p - 3)$ distinct normal modes of vibration of the crystal lattice.

The foregoing considerations are, of course, purely classical, but their validity is re-inforced when we consider the problem in the light of the general principles of the quantum theory. For this purpose, we may take the case of a crystal the unit cells of which contain each one molecule composed of p atoms linked together. In the absence of interactions, the $3p$ degrees of freedom of the atoms in the cell appear as the 3 translations and $(3p-3)$ quantised rotations and vibrations of the molecule. Neighbouring molecules having the same frequency would have the same energy and therefore the same amplitude of vibration, but their phases would be uncorrelated. The interactions would however result in specific phase relations being set up and also influence the common frequencies of vibration in a manner determined by the phase relations thus arising. A common frequency of vibration involves a homogeneous set of phase relations throughout the assembly, and, on the basis that the phases are either the same or opposite, there are just 8 possible ways in which they could be arranged. Accordingly, each mode of vibration of the individual molecule would split up into 8 distinct modes of vibration of the assembly. Assuming that the interactions are strong enough to prevent free rotations of the molecules, we thus obtain $(24p - 3)$ distinct quantised modes of vibration of the assembly. Each of these, of course, must be regarded as being very highly degenerate.

Remarks on Some Earlier Theories

The result thus emerges that the vibration spectrum of a crystal lattice is a discrete line spectrum exhibiting a finite set of monochromatic frequencies. The number of discrete frequencies would be further diminished if the crystal has additional symmetry properties, since several of the distinct normal modes would then have identical frequencies. We may mention a few cases by way of example. A simple face-centred or body-centred cubic lattice would have 4 distinct frequencies of atomic vibration, the diamond lattice would have 8 distinct frequencies and the rock-salt lattice would have 9 such. The modes of vibration in such simple cases can be fully described on the basis of symmetry considerations alone. More generally, however, a detailed investigation would be necessary to find the exact nature of the individual normal modes.

The whole of the present generation of physicists has been brought up to believe in the notion first put forward by Debye in 1912 that the thermal energy of a crystalline solid may be identified with the energy of vibrations of the elastic solid type occurring in it. This idea leads to the result that the frequency spectrum of the atomic vibrations in the crystal is a continuous one, in striking contrast with the conclusions reached above, which indicate that even for the simplest crystals it is a discrete line spectrum of monochromatic frequencies. The reasons for this discrepancy are not far to seek and are, in fact, to be found in the essential illegitimacy of Debye's assumptions. The fact that the specific heat of every crystal attains the value given by the law of atomic heats when its temperature is sufficiently raised, as well as the actual course of the curve by which this value is reached clearly show that we are concerned with the vibrations of the individual atoms in the crystal and that the problem is therefore essentially one of particle dynamics and not one of wave propagation in a continuous solid. Further, the frequencies of vibration which determine the course of the specific heat curve lie, for the most part, well beyond the range where the theory of wave-propagation in an elastic solid can with any show of justification be regarded as applicable. This is readily seen from Debye's own calculations which indicate that by far the largest proportion of his "waves" have lengths of the same order of magnitude as the lattice spacings of the crystal. The invalidity of the Debye theory becomes clearest when we examine the question of "counting" up the modes of vibration of the system. "Waves" as such are not enumerable, since they may be assigned any arbitrary wavelength and consequently arbitrary frequency. Hence, a count of them is meaningless unless it can be shown that only certain discrete wavelengths with correspondingly defined frequencies are allowed and that all the others are excluded by the very nature of the case, thereby enabling the vibrations to be identified with the normal modes of the system which are enumerable according to Lagrange's fundamental theorem. It is not possible to escape this difficulty by regarding the waves as equivalent to "stationary vibrations" in an elastic solid continuum, since we are principally concerned with vibrations of such high frequency that the lattice structure of the crystal is of the very essence of the problem.

Difficulties of the same kind arise in an even more acute form when we proceed to examine the logical foundations of the theory of lattice vibrations in crystals developed by Max Born and his school. The whole framework of the Born theory rests upon the idea that, since the "boundary conditions" cannot be specified, something should be found which could replace them and by which the fundamental difficulty may be overcome of enumerating the "waves" with which the vibrations of the system are identified. The postulate of the cyclic lattice is introduced in the theory with this object. It provides the requisite number of "waves" whose lengths determine both the so-called acoustic and optical oscillations of the lattice. As in the Debye theory, the "waves" thus chosen are most numerous in the region of wavelengths nearly comparable with the lattice spacings of the crystal, with the result that both the "acoustic" and "optical" vibrations are spread out into "branches" extending over a wide range of frequencies—as is indicated by the calculations made by the Born school for the few cases in which the ideas have actually been worked out.

The artificial character of the cyclic postulate is very obvious, and it is sufficient to point out that it does not achieve the purpose for which it has been introduced. Born's own equations show that, if the vibrations of the medium are regarded as waves, then the wavelengths can be chosen quite arbitrarily. Unless therefore it can be shown that the particular choice made is uniquely demanded by physical reasoning—which is necessary if the resulting motion is to be identified with normal vibrations in the Lagrangian sense—the frequency spectrum determined by such arbitrary choice of wavelengths can have no possible physical meaning or significance. Indeed, it is plain that the "waves" of the Born theory have no claim whatever to be regarded as the normal modes of vibration of the crystal lattice.

Experimental Configuration of the New Ideas

The theoretical result that the vibration spectrum of a crystal lattice is a discrete or line spectrum of monochromatic frequencies is naturally subject to the restrictions implied in its derivation. The theory is based on a consideration of small oscillations under harmonic forces in an ideal lattice. Departures from perfect monochromatism of the vibrations are naturally to be expected when these simplifying restrictions are removed, *viz.*, when we consider oscillations of finite amplitudes, an-

harmonic forces and crystal lattices which are imperfect or which are disturbed appreciably by thermal agitation. These may be minimised by working under appropriate conditions, and the most decisive results are naturally those obtained with crystals most nearly approaching ideality and held at a sufficiently low temperature. Various methods of investigation are available, *viz.*, the spectra of light-scattering, luminiscence and absorption in crystals and a vast array of experimental evidence gathered during the last two decades by these and other methods of exact spectroscopic research is on record, to which the interested reader may be referred.

Of special interest are the recent investigations of Dr. R. S. Krishnan (*Nature*, 159, 1947, p. 60) on the scattering of light in diamond observed under high resolving powers which give a direct objective demonstration of the monochromatic character of the atomic vibrations in that crystal and simultaneously furnish an experimental refutation of the ideas underlying the older theories. Analogous studies with various other crystals, *viz.*, rock-salt, ammonium chloride, ammonium bromide, corundum, topaz, etc., have also been carried out by Dr. R. S. Krishnan and the results obtained by him are particularly significant in view of the fact that they have been carried out under critical experimental conditions, *viz.*, using the highest possible spectroscopic resolving powers and also working with the crystals held at a series of temperatures down to that of liquid air. The detailed results of these investigations will shortly be published as a Symposium on the Vibration Spectra of Crystal Lattices by the Indian Academy of Sciences, which will also include a complete review and theoretical discussion of the entire body of spectroscopic evidence available up to date from the most exact investigations on the behaviour of crystals made by investigators in various countries. It emerges unequivocally from these studies that the theories which suggest that the atomic vibrations in crystal lattices give a continuous spectrum are in clear contradiction with the experimental facts and are therefore wholly unsustainable.

C. V. RAMAN.

THE SHRI RAM INSTITUTE FOR INDUSTRIAL RESEARCH, DELHI

THE laying of the foundation-stone of the Shri Ram Institute for Industrial Research constitutes a landmark in the development of Industrial Research in this country. In the inspiring words of Sir Shri Ram, the founder himself, "Our industries have so far been very much unmindful of the needs for industrial research. Expenditure on industrial research which our industries and the Government have so far done is negligible compared to what has been done in other industrially advanced countries, with the result that these countries have made great progress both in technique and organisation of industries and our country has lagged behind. Thus the establishment, all over the country, of a number of industrial research institutes with roots deep in applied and fundamental research is imperative. The inspiring example of the contribution of the Mellon Institute of Industrial Research at Pittsburgh in the United States of America should be the guiding star for all our efforts." The same idea has been further emphasised by Sir Maurice Gwyer who prefaces the prospectus of the Institute with a Foreword, writes, "The imperative need for research on the scientific side into the fundamental problems of industry is now generally recognised. The Universities and Technological Institutes have their own functions. The Universities, apart from the instructions which they provide, are or should be, concerned with the problems of what is sometimes called pure science; the Technological Institutes with the broad general principles of technology, which are themselves based on the researches of pure science. An industrial Research Institute is concerned rather with the application of the principles of pure science and of technology to the problems of industry as they arise. Many of these problems do not admit of solution without further research into the fundamental principles both of pure science and of technology; and hence the scope of an Industrial Research Institute is at once both broader and narrower than that of Universities and Institutes of Technology. No industry can at the present day afford to neglect scientific research into its own problems; nor can it in any country be content to rely upon research work done elsewhere."

India is on the threshold of a great industrial revolution; post-war plans on ambitious and gigantic scale but in harmony with the great potentialities of this country, have been drawn up. The men and the means of accomplishing the tasks facing the country have got to be provided. Sir Shri Ram Institute, which owes its inception to the patriotic munificence and the far-seeing vision of Lalaji is expected to play its part in a planned and rationalised industrial development of India.

THE NATIONAL PHYSICAL LABORATORY OF INDIA, DELHI*

By SIR S. S. BHATNAGAR

(Director, Scientific and Industrial Research)

The Genesis

IN the year 1941, the Director of Scientific and Industrial Research represented to the then Commerce Member, Sir Ramaswamy Mudaliar, who was also the founder of the Council of Scientific and Industrial Research, that the prime essential for India's industrial development was a Central Research Laboratory, separating as it developed into a National Chemical and a National Physical Laboratory. Already the Government had provided us with a laboratory at the Government Test House in Calcutta to make a beginning in the matter of organising scientific and industrial research in the country to meet national and defence needs necessitated by the war. I proposed in a note both an expansion of the Government Test House and the creation of new laboratories in Calcutta, Delhi or other places climatically more suited. These proposals were still under examination when the entry of Japan into the war changed the situation completely and it became clear that any expansion of activity at Calcutta was out of the question, since Calcutta was obviously vulnerable to air attack. So, it was decided to remove the laboratories of the Director of Scientific and Industrial Research to Delhi and continue the work of the Board at the headquarters of the Government.

The idea of establishing a twin-set of laboratories, the National Physical Laboratory and the National Chemical Laboratory, was accepted in the beginning of 1943 by the then formed Council of Scientific and Industrial Research. Soon after, the idea was widened in scope and the Council approached the Government of India for the grant of a crore of rupees for the post-war establishment of five National Laboratories, the three additional ones being, a National Metallurgical Laboratory, a Central Glass and Ceramic Research Institute and a Fuel Research Institute. Planning Committees consisting of some of the best available scientific and technical talent in the country were set up to prepare broad plans for the work, functions and organisation of each of these laboratories.

It is necessary to stress here the nature of the National Laboratories. These laboratories do not intend to supplant but to supplement the work of individual or collective industrial concerns in respect of research. They undertake work of the kind that does not come ordinarily under the scope of industries. Since they are able to command resources wider than the industries can, the laboratories can employ more talent and try alternative approaches to problems simultaneously. Problems which bear wider social aspects than an industry could be concerned which become subjects of state scientific research. Moreover, the advice that state research can give will be non-partisan. Industry can hardly undertake work of a purely exploratory nature. So the function of these laboratories is both complementary and independent.

The Planning Committee

The Planning Committee for the National Physical Laboratory consisted of Sir Ghulam Mohammad as Chairman and as members, Prof. M. N. Saha, Dr. Nazir Ahmad, Sir K. S. Krishnan, Principal G. R. Paranjpe, Dr. H. J. Bhabha, Dr. Wali Mohammad, Dr. D. M. Bose, Dr. Rafi Mohammad Chaudhry and Mr. N. N. Sen Gupta and myself. Besides these members, the Council obtained the services of Dr. K. N. Mathur from the University of Lucknow as Assistant Director for planning and as Secretary to the Committee. Following the usual procedure of the Council's Planning Committee Reports, the National Physical Laboratory Report was first drawn up in a tentative form and was widely circulated, to invite comments and suggestions, both in India and abroad. The response the Committee received could, perhaps, be taken as an index of the general interest in the Laboratory. Besides a volume of comments and suggestions from individual scientists, scientific institutions and Government Departments in India, we had the benefit of the advice of the President of the California Institute of Technology, Prof. Robert A. Millikan, the Director of the National Bureau of Standards, Dr. Lyman Briggs and the Director of the National Physical Laboratory (of England), Sir Charles Darwin. In England, the National Physical Laboratory, situated in the picturesque surroundings of the Bushy Park has established an envied reputation for itself. Its tests and certificates are taken as the hall-mark of the highest precision and accuracy which scientific knowledge and human ingenuity can attain. As members of the Scientific Mission which visited U.K. and U.S.A. in 1945 some of us had the privilege of a free discussion with Sir Charles Darwin and members of his staff on the tentative proposals for the National Physical Laboratory. This discussion and the suggestions received, enabled the Planning Committee to finalise their report which was published early this year and was accepted by the Governing Body of the Council.

Organisation and Function of the National Physical Laboratory

In the main, the Laboratory's foremost function will be the maintenance of fundamental and derived standards, and the undertaking of research with a view to achieve greater and greater accuracy in the measurement of those standards. At present there is no well-equipped laboratory in India which can undertake standards work. One or two laboratories in

* Edited extracts from the Address delivered by Sir S. S. Bhatnagar, Kt., O.B.E., D.Sc., F.R.S., on the occassion of the Foundation Stone Laying Ceremony of the National Physical Laboratory during the first week of January 1947.

India possess yard and metre bars which were at one time standardised by the National Physical Laboratory at Teddington. The Mint at Bombay have in their possession certain standard weights certified by the National Physical Laboratory of England. But in neither case any systematic organisation exists to undertake regularly inter-comparisons between their standards and those of the other countries, which is the accepted method of all standards laboratories. Besides the fundamental standards of length, mass and time, there is a large number of derived standards like volume which comes in so much in chemical glassware, and in gallon measures of liquids; the various electrical units against which all the electrical measuring work of the scientists, the electrical industry and the electric supply companies is standardized; density measurements, which are of use not only to the scientists but also to the layman. The Lactometer interests the housewife as a handy weapon in her constant travail against the quantity of water in domestic milk supply. Perhaps, one of the biggest contributions which the National Physical Laboratory in England made under the able direction of Sir Charles Darwin was their organisation for testing gauges for the industry during the war time. We are on the threshold of a great industrial development in the country in which the development of engineering industry is expected to play a very great part. No precision work in engineering can be done without an adequate supply of calibrated gauges, and some organised laboratory where these gauges could be checked and rechecked periodically since gauges wear off with use. This point may be better appreciated if I were to say that in the fittings of high grade automobiles and aero-engines an accuracy better than one part in ten thousand is usually required in individual parts. At the National Physical Laboratory at Teddington, gauges are tested to an accuracy of better than one part in a million. In the calibration of the standard weights they have reached an accuracy of one part in ten million through the use of a special type of balance and accurate control of outer conditions.

Nine Divisions

The work of the laboratory in India will be carried on through the following nine Divisions:—

(1) Weights and Measures.
(2) Applied Mechanics and Materials.
(3) Heat and Power.
(4) Optics.
(5) Electricity.
(6) Electronics and Sound.
(7) Building and Housing Research.
(8) Hydraulic Research.
(9) Analytical Chemistry.

Each of these divisions will be under an Assistant Director, who will have under him scientific assistants besides other laboratory staff.

Liaison with Industry

Apart from the work of standardisation the laboratory will be called upon to undertake considerable amount of research work which is expected to go a long way towards developing Industry in this country. Physical science is taking long and fast strides. New discoveries in the fundamental sciences are opening up vast possibilities of industrial application both by way of improving old processes and by introducing new ones. The National Physical Laboratory will be concerned with maintaining constant research work to fulfil this purpose. For the same reason they will maintain a close liaison with Industry. Investigation of raw materials of the country with a view to adopt them to the requirements of the industry will be a correlative work which the laboratory will undertake.

Industrial Standardisation

A very important aspect to which sufficient attention has not been given in this country is that of industrial standardisation. It may be recalled that the Government of India recently set up a body known as Indian Standards Institution, which will undertake industrial standardization in India on somewhat the same lines as the British Standards Institution does in the U.K. The work of the B.S.I. is carried on mainly through the active assistance of scientific laboratories. The National Physical Laboratory in England has contributed not a little towards the success of industrial standardisation there in all branches which lie within the scope of their work. The Council of Scientific and Industrial Research have been associated intimately with the formation of the Indian Standards Institution and Dr. Mathur recently represented them at the British Commonwealth Standards Conference and the International Conference on Standardisation, held in London in October last. At both these conferences, measures for a better co-ordination of industrial standardisation were discussed. If India is to play her role as a great nation she has to take an active part in scientific and technological work of an international character quite as much as in the international political sphere. Speaking from experience, I can say without hesitation that the amount of unanimity which the scientists are able to achieve is quite unimaginable amongst politicians. The National Physical Laboratory Planning Committee has rightly laid great stress on the point that the Laboratory shall in all possible ways assist Industrial Standardisation.

Fundamental *vs.* Applied Research

The subject of fundamental *versus* applied research has been recently heard in many quarters. In the minds of those qualified to speak research can hardly be divided into water-tight compartments and such division is a scholastic distinction which ignores how scientific research develops. What is fundamental to-day, may become very much of applied research in a very short while. The electrical dynamo was as much the result of fundamental work on the nature of electricity as the development of atomic energy the result of abstract calculations of the nuclear physicists. Both the theoretical and practical aspects of science have thus progressed by their intimate interplay. An artificial separation is neither theoretically sound nor practically workable and if enforced renders theory arid and practice a petrified routine. *It is by the inter-pollination*

of thought and work that the most fruitful result emerges. I am glad to state the Council of Scientific and Industrial Research has been keenly alive to this and has given as much encouragement to research of a purely academic type as to applied or utilitarian work. As instances, the Council's grant to Tata Institute of Fundamental Research, the Palit Research Laboratory of Calcutta, the Bose Research Laboratory, and the several research schemes in operation under the auspices of the Council bearing on fundamental aspects of sciences may be mentioned. The Planning Committee of the National Physical Laboratory have also stressed the importance of encouragement to both these aspects of research.

Fundamental Research To-day—An Organised Industry

One aspect of fundamental research work which can hardly be neglected in India is that which requires specialised large-scale laboratories. During recent years, and particularly during the last world war, organisation of scientific work has undergone vast changes. Not only does some of the present type of work require large-scale specialised organisations well outside the scope of university work but also expenditure of money running into millions which could only be justified if diversified, co-ordinated and regulated application and professional continuity of work are guaranteed. This is not usually possible in the universities where teaching and research necessarily go hand in hand and are essentially preparatory. Research work there, is bound to be scrappy, discontinuous, and unco-ordinated. I may be permitted to quote here from a recent article by Dr. Lee A. Dubridge who is now President of the California Institute of Technology and who during the war was Director of the Radiation Laboratory at the Massachusetts Institute of Technology which had such a lot to do with the conduct of atomic energy development in the U.S.A. Discussing the importance of large research laboratories, Dr. Dubridge says "... it should be clear that independent laboratories will have as their major facilities only those very large installations which, as far as can be foreseen, are beyond what a single university could contemplate operating—or which, because of shortage of material or funds, not more than one or two universities in any area could have. So, I, for one, look forward with keen interest to a great new experiment in physical research. Those who long for the old days with lone worker in the basement room with his wax and string and glass-blowing torch can have them. I believe that the essential spirit of the old days—freedom of enquiry, time for thought—can be obtained even in the pressure of great new physical and organizational techniques." In short, fundamental research is soon becoming a huge organised industry in itself.

Location of the Laboratory

The question of location of the National Physical Laboratory was thrashed out threadbare and the Committee made out an overwhelming case in favour of locating the Laboratory at the headquarters of the Central Government. In any new constitution the importance of contact between science and state will even be greater. Delhi, besides being the seat of a young and hence very virile university, is in addition the headquarters of a number of scientific departments of the Government of India like the Meteorological Department, the Agricultural Department, the Medical Department, the Royal Indian Air Force, the Scientific Section of the G.H.Q., the All-India Radio, the Railway Board and others. We are particularly fortunate in the present site as we are close neighbours of an Institution which has played no inconsiderable part in India's agricultural development—I mean the Agricultural Research Institute right opposite us. The Institute has one of the best libraries on the biological sciences, and between the National Physical Laboratory and the Institute, we shall have the most complete scientific library in India which we hope will form the nucleus of a Central Information Service for all the scientific workers in India.

These are days of decision for India and if she is to take, as she must, her rightful and honoured place among the nations of the world she must grow strong and great industrially. In this great and exacting venture the role of the national laboratories will be vital and the people of our country, whose mind and face are already turned towards science in industry and society, will, I am sure, take great interest in the work of the laboratories and extend their unflagging help in their development.

APPLIED ENTOMOLOGY, ITS PAST AND FUTURE IN INDIA*

DR. BHALERAO has been recognized as one of the authorities on Indian Helminthology, and as one who has devoted himself to the subject for the past twenty years, he is in the best position to correlate all our accumulated knowledge of Helminth parasites. He has himself contributed to the elucidation of the life-histories of a number of helminths, either directly or indirectly affecting man and has, in the address, listed all the parasites that have been reported from time to time in this country. Working in one of the premier Research Institutes of India (Imperial Institute of Veterinary Research), it is natural that the parasites of domestic animals get their full attention in his address and a long and comprehensive list is presented of trematodes, cestodes and nematodes occurring in animals that are associated with man's life in India. In a necessarily brief address such as this, it is naturally impossible to expect comprehensive accounts of the life-history of each species. In fact, in quite a number of cases, the life-history is unknown. That is where Dr. Bhalerao's address is a help, in drawing attention to the vast amount of work that is still to be done, and the large number of gaps in our knowledge still to be bridged. Brief references are made in the case of each parasite, to its host, to the disease it causes, and also in such cases where the life-history is fully known, to the remedies.

* Summary of Dr. G. D. Bhalerao's Presidential Address to the Section of Zoology and Entomology, Indian Science Congress, Delhi, 1947.

THE YELLOWING OF BLEACHED JUTE

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THERE is good reason to believe that pure, undegraded cellulose (not holocelluloses) if stored in the dark in a vacuum at low temperatures would retain its whiteness almost indefinitely. At the other extreme, bleached cellulosic fibres containing a high proportion of non-cellulosic impurities are known to become brownish or yellowish fairly quickly during ordinary storage. Exposure to light, as in the case of partly bleached jute, may accelerate the process. Storage at a high temperature also hastens the discoloration. There are various intermediate conditions of purity and storage and the part played by all the factors cannot be said to be well understood for vegetable fibres in general, though in the case of cotton and linen a good deal of information is available. The present preliminary note is concerned with the yellowing of bleached jute on storage, particularly of jute bleached by means of sodium chlorite without thorough scouring.

In the case of cotton and linen the presence of degraded cellulose (oxycellulose or hydrocellulose) is known to cause a yellowish discoloration in storage. Moreover, it is known that linen which has not been well "bottomed" (well scoured with boiling alkaline solutions) is liable to lose its whiteness in storage. Here the hemicelluloses (of which flax, like jute, contains some 20 per cent.) remain in the bleached goods. The role of naturally occurring fats and waxes is less well-known, though experiments with cotton have shown that the effect of residual wax is negligible. The effect of so-called "chloramines" has not been quite clearly separated from other factors, but it is certain that partly bleached linen which has not been antichlored and contains substances, whatever they may be, which liberate iodine from acidified potassium iodide is liable to rather rapid yellowing.

It is obviously impossible to ascribe the yellowing of bleached vegetable fibres in general to any single cause. Fibres vary greatly in composition, for example, in cellulose content, lignin content, hemicellulose content, and the nature of the bleaching process is also subject to great variation, as in thoroughness of scouring, the chemical used for the oxidative treatment and its conditions of use (strength of liquor, reaction, duration, temperature), use of antichlors, thoroughness of washing and so on. Some of the views that have been held are illustrated by the following examples. Kuchinka,[1] studying the linen bleaching process, held the oxidation products of cellulose to be the cause of yellowing. A similar view is taken in a patent[2] of the Mathieson Alkali Works, it being claimed that the use of sodium chlorite ("Textone") produces less oxycellulose than the use of hypochlorites and gives a more permanent white. Ridge and Little[3] suggest that the complete removal of lignin is necessary in order to obtain a white that does not yellow on exposure to light. Giertz,[4] however, could not trace the discoloration of bleached woodpulps to any degradation product of lignin and considered that yellowing was due to the decomposition products of hemicelluloses. Elgin,[5] in describing a patent, holds the natural pigments of lignified fibres to be responsible for yellowing and claims that their removal by organic solvents permits a brilliant permanent white to be obtained by bleaching with hydrogen peroxide, indicating that the process is applicable to jute.

Jute bleached by a process which includes thorough scouring with alkalies and careful treatment with hypochlorites will show a good, permanent white, but the natural cement which joins together the short ultimate fibres is removed in such treatments and the fibre has little or no strength, especially when wet, resembling in this respect papers made from wood-pulp. The problem is, therefore, to discover a means of removing the substances which are responsible for yellowing without removing the intercellular cement; any process that involves thorough scouring, or even mild hot alkaline treatments, must be avoided if good wet strength is to be obtained.

The observations to be described do not solve the problem, and the production of a really full permanent white on jute, if not impossible, is clearly a matter of great difficulty. Some light is, however, thrown on the matter and the result obtained when bleached jute was stored under alcohol seems to be of considerable importance in suggesting lines of attack.

The after-yellowing of jute bleached, or delignified, without scouring, by means of sodium chlorite has been examined in the course of our work during the past two or three years and the following observations are now recorded.

(1) Jute completely delignified by treatment with sodium chlorite develops a yellowish colour on exposure to light and air or on heating for a few hours in the dark and this occurs to approximately the same extent whether or not the fibre has previously been extracted with alcohol-benzene in a soxhlet. It may be concluded that the fats, waxes, etc., removable by alcohol-benzene are not responsible to a very important extent for the after-yellowing. Moreover, since it has been shown by Chatterjee and Sarkar[6] that removal of lignin is complete by treatment with sodium chlorite under the conditions employed, the yellowing, observed on storage in diffused daylight for a few months or on heating to 105° C. for a few hours, is not due to presence of lignin itself. Of course, in jute bleached by treatments that leave part of the lignin in the fibre, the lignin may contribute to the yellowing that is observed. The most obvious possibilities that remain are that the yellowing is due to (*a*) small quantities of lignin decomposition products, (*b*) hemicelluloses or degraded hemicelluloses and (*c*) degraded cellulose, for

example, oxycellulose, and experiments have been made in an attempt to narrow down this field.

(2) In order to remove lignin decomposition products that may remain in small amounts after treatment with sodium chlorite, the delignified jute was extracted at room temperature with dilute solutions of (*a*) sodium bisulphite, (*b*) sodium sulphite, (*c*) sodium thiosulphate, (*d*) sodium bicarbonate, (*e*) ferrous ammonium sulphate, (*f*) caustic soda, (*g*) calcium hydroxide. The fibre still showed considerable yellowing in all cases when heated to 105° C. for three days, but it was less than in samples that had not received the subsequent treatment, particularly in the treatments with caustic soda and calcium hydroxide. Extraction of the delignified fibre with alcohol, acetone, chloroform or benzene did not prevent after-yellowing. We have not yet attempted to ascertain to what extent the treatments with sodium sulphite, etc., actually remove lignin decomposition products that might be present or to determine to what extent there was a simultaneous removal of hemicelluloses, degraded hemicellulose, or degraded cellulose but it is likely that sodium sulphite, for example, is effective in removing lignin decomposition products and the fact that considerable yellowing still occurred points to the conclusion that hemicelluloses, of which at least 20 per cent. occur in the raw fibre, play an important part in the yellowing. Delignification by means of sodium chlorite under the conditions employed leaves the hemicelluloses practically intact.[6] It is known, too, that jute partially bleached by the use of mild alkaline treatments in conjunction with hypochlorite treatments is subject to considerable after-yellowing. In such treatments it is clear from the loss in weight (say 8 to 15 per cent.) that much of the hemicelluloses remain. Sodium chlorite is known to be mild in its action on cellulose and an important contribution to the yellowing by oxycellulose produced during delignification is unlikely. Further evidence of the part played by hemicelluloses in the yellowing is given by the following observations.

(3) Cellulose prepared from jute by Cross and Bevan's method is entirely free from lignin but retains some of the hemicelluloses.[6] It shows some yellowing on prolonged storage in diffused light, though much less than the holocellulose obtained by the chlorite treatment of defatted jute. This is regarded as partly due to the presence of oxycellulose and partly to the presence of residual hemicelluloses, though the importance of each is not easy to assess.

(4) As shown by Chatterjee and Sarkar (*loc. cit.*) partial removal of hemicelluloses by treatment with dilute (half per cent.) caustic soda at about 31° C., prior to delignification with sodium chlorite, materially diminishes the tendency to yellowing on heating at 105° C. The effects of other preliminary alkaline treatments were also examined and it was found that the more severe the treatment, the less is the tendency towards after-yellowing in the delignified fibre. It appears, therefore, that the lower hemicelluloses—those removable by the milder alkaline treatments—play an important part in the yellowing. Cross and Bevan's cellulose and Norman and Jenkins's cellulose have lost the lower hemicelluloses and show a small tendency to yellowing, comparable with that shown by the sodium chlorite cellulose that has received a mild preliminary alkaline treatment.

(5) Cellulose prepared by treatment with moist chlorine dioxide becomes yellow very quickly on storage or on heating; the yellowing is much more rapid than with chlorite cellulose. This is attributed to the combined effect of the practically complete retention of hemicelluloses and of the degradation of both cellulose and hemicelluloses, the latter condition being indicated by the high copper number (Chatterjee and Sarkar, *loc. cit.*)

(6) Jute extracted with alcohol-benzene and then delignified with sodium chlorite did not become yellow even in fifteen months when stored immersed in alcohol, in a large boiling-tube, in diffuse day-light. This is presumably due to the virtual exclusion of oxygen from the holocellulose, the alcohol being preferentially oxidised by any oxygen that passes into it. Both reducing and acidic products were detected in the alcohol. A sample of delignified jute stored under benzene is being kept under observation, but it is too early to report results.

(7) By treatment with dilute alkali at room temperature the dull yellow colour of delignified jute, developed during storage, can be removed almost completely. It is yet to be seen whether the treated samples again turn yellow during storage, though, as stated in Section (2) above, an improvement has already been found after treatment with dilute caustic soda.

Conclusion: The foregoing observations are consistent with the view that the hemicelluloses of the jute fibre, which form at least 20 per cent. of its bone-dry weight and are retained in delignification by means of sodium chlorite, are largely responsible for yellowing during storage. They may suffer some degradation during the chlorite treatment and further degradation in storage by light and oxygen would explain the results observed. Yellowing of the hemicelluloses, or degraded hemicelluloses is not, of course, regarded as the sole cause of yellowing of bleached jute. If, in addition to hemicelluloses, the bleached fibre contains residual lignin, or lignin degradation products or a considerable proportion of degraded cellulose (*e.g.*, oxycellulose) yellowing may be expected, and other non-cellulosic impurities may play a part. The practical bearings of the matter lie in the fact that if, as it appears, hemicelluloses play a major role in yellowing, it becomes very important to study the possibilities of removing hemicelluloses, or that portion of them which is mainly responsible for the yellowing, without unduly detracting from the strength of the fibre, particularly its wet strength. It is known that even mild alkaline treatments, before or after treatment with chlorite or hypochlorites, may very considerably reduce the wet strength; the problem is, therefore, a difficult one. Lignin cannot in practice be removed without some oxidative treatment (as with hypochlorites, chlorites, peroxides, permanganates) and such treatments cannot be given without producing some oxycellulose. Treatments to remove oxycellulose

and to remove hemicelluloses must include alkaline treatments, with the danger of removing the intercellular cement, at least in part. A compromise seems indicated—the use of the mildest oxidative and alkaline treatments that will give a worth-while result; pure cellulose will not be obtained and some after-yellowing must be faced. The problem is to find the conditions that give the best compromise. The alternative is to scour thoroughly and chemick mildly obtaining practically pure and very slightly degraded cellulose but very poor yarn or fabric strength; then we may attempt to introduce an artificial resin to replace the natural cement lost in bleaching.

Whether it may be possible to put some substance on the bleached fibre which, like alcohol, will be preferentially oxidised and so prevent yellowing for a considerable period remains to be seen. There are many difficulties; the substance would, in the case of goods that are exposed to the weather, have to be insoluble in water and in the case of goods that are to be laundered, it would have to be fast to washing. Laundering presents its own problems; we may produce a bleached jute material that retains fairly good wet-strength but experience shows that in repeated launderings there is a progressive loss in strength, no doubt due to the progressive removal of the inter-cellular cement. This has caused difficulties with tropical suitings made from a cotton warp and a partly bleached jute weft.

1. Kuchinka, *Melliand Textilber.*, 1939, **20**, 643, 706, 759, 804. 2. B. P., 561, 834 of the Mathieson Alkali Works, New York. 3. Ridge and Little, *J. Text. Inst.*, 1944, **35**, 134. 4. Giertz, *Svensk Papperstidn.*, 1945, **48**, 317. 5. Elgin, *U.S. Patent*, 1945, **2**, 372, 561, Princeton. 6. Chatterjee and Sarkar, *Proc. Nat. Inst. Sci.*, 1946, **12**, 23.

FOREIGN CO-OPERATION IN THE DEVELOPMENT OF INDIAN INDUSTRIES

IN the course of his Presidential Opening Remarks at the Third Quarterly Meeting of the Central Committee of the All-India Manufacturers' Organization, held on December 22, 1946, Sir M. Visvesvaraya revealed that there had been offers of co-operation for starting new industries or companies in India. Some foreign business firms were ready, on reasonable terms, to work out new schemes, tender technical advice and arrange to procure and supply the machinery needed. Some of those firms were prepared to find capital if reliable groups of industrialists in this country felt the need.

During their discussions with the associations and business men, consulting engineering firms and others, he said that they took care to tell them again and again that promoters of new industries here were not likely to accept technical advice, machinery or even share capital for industries in India unless the control of every such concern was in Indian hands. He felt that this condition could be assumed and suggested that if the Government had no particular objection, groups of industrialists or business men, eager to establish new heavy industries in any part of the country, might be encouraged to begin collecting preliminaries and making preparations with a view to starting construction at the earliest favourable opportunity.

He had often thought that the importance of industries was not correctly understood by the people of India. In no country were industries promoted unless political power was behind it. In the absence of any sound industrial policy or drive on the part of the Government, the business public had been suspicious and slow in investing in industries. As has often been said, a balanced development of both Agriculture and Industries was essential for increasing the earning power and standard of living of our people. As far as possible all ordinary wants in the shape of consumer goods should be met by local production. Success in modern warfare was preponderatingly dependent on armament machinery, which was a product of highly developed skill, particularly in the manufacture of engineering industries. Industrial progress was vitally connected with the defences of a country.

Concluding his address, Sir M. Visvesvaraya declared that "now even more than formerly, in this closer-knitting of the world, the men with knowledge and skill will have the upper hand everywhere and the ignorant and the unskilled will be relegated to a subordinate place under some one or other strong power.

"In our country, peoples' thoughts and practices are still guided to some extent by religion and tradition. Tradition is often a wrong guide in the face of modern discoveries. Americans have been almost always against it and they take every opportunity to carry out reforms and developments. Hence they have become the most prosperous and powerful nation in the post-war world.

"If we educate our 340 million population, now illiterate, and teach them modern business habits and practices, the country will acquire enormous power for increasing production and good living.

"People in India should be economically united as are people in the United States of America, Canada and the United Kingdom. The nation-building activities I have referred to cannot be delayed without great loss. Unity among the population is required for its economic safety even more than the political. Economic unity cannot be delayed without further impoverishment of the population and curtailment of their subsistence needs. The chief elements of progress are unity of purpose between the Government and the people, team spirit in industry, co-operation between all classes of population in business and social life, and a strong resolve to work more and work better on the part of every individual citizen and his family. If the Government and the people become united in policy and action in this way rapid progress will be speedily achieved and the country will be bringing into existence a new national life."

SEASONAL RELATION BETWEEN NORTH AMERICA, SOUTHERN MONSOON AND WINTER RAIN IN NORTH-WEST INDIA

By S. L. MALURKAR

(*Poona* 5)

THE south-west monsoon is dependent on the incursion of equatorial maritime air (Em) from the south. A series of low pressure area or 'pulses' moving westwards just south of the equator cross into the northern hemisphere and give rise to Em there.[1] These low pressure areas or 'pulses' could be traced to the high pressure area over South America[2] in southern winter. Climatic charts show that the winds in S.E. Pacific Ocean west of North Chile and of Peru are steady and moderate to strong during that period. If the northern or north-western portions of the high pressure area about this region are considered, the resulting wind stream would be easterly.

During the pre- and post-monsoon months in India, the northward passage of the 'pulses' is necessary for the formation and maintenance of tropical cyclonic storms or depressions.[3]

In southern summer, fresh 'pulses' from the north cross over to the southern hemisphere to form and maintain tropical cyclonic storms and depressions and help to intensify the seasonal low pressure area there. These 'pulses' can also be traced to the east of the place where they crossed over into the South Indian Ocean along the corridor of low pressure just north of the equator and south of the winter Asiatic high. The climatic charts show that the winds in the north tropical region of East Pacific (west of California and Mexico) are steady and moderate to strong due to the high pressure area over the United States of America and North Mexico in the northern winter. The arguments of advection of air from this region to the South Indian Ocean would be similar to that used for the Indian Monsoon and the time lag of 30 to 45 days would be equally applicable.[4] The 'pulse' that enters the South Indian Ocean would be one of the secondaries of the low pressure area originating from the southern or south-western portions of the North American high. The main factor that controls the monsoon in the South Indian Ocean with a positive relation should be the pressure of the south or south-western portions of the North American high a month or a month and a half before the epoch considered. The regions that can be expected to modify the passage of the 'pulse', once it has left North America, are :

(*a*) The low pressure area over the North Pacific Ocean should not be too marked or extend to too southerly latitudes.

(*b*) The winter high pressure area over Asia should not extend too far south in the pacific as then the 'pulse' would move into the S. Pacific.

(c) The seasonal high pressure area over the S. Pacific should be well developed and this prevents a premature crossing of the 'pulse' into the S. Pacific.

(*d*) The seasonal high pressure area over the western regions of Asia should be well developed to allow the 'pulse' to cross into the S. Indian Ocean.

(*e*) The seasonal low pressure area in the S. Indian Ocean must be normal in position and intensity.

(*f*) The general circulation (also wind speed) north of the equator must be adequate.

The time lag between these factors and the epoch of the southern monsoon decreases successively so that the time between the crossing of the equator by the 'pulse' and strengthening of the monsoon low in the south may be about three to four days.

The southern monsoon low pressure stretches over the South Indian Ocean and a foreshadowing of the seasonal weather there has not a great practical value and would not be quite exciting as in the case of the Indian monsoon which affects a considerable portion of the world population.

An indirect effect of the southern monsoon over N.W. India is important from the point of view of wheat crop there. The winter rain over N.W. India is due to 'western disturbances' which are often diffuse secondaries of extra-tropical depressions moving from west to east. The rainfall and movement of these diffuse and complex low pressure areas become clear if they are separated out into successive secondaries all of which move (with varying speeds) in an east-north-easterly direction.[5] In the absence of tropical cyclonic storms or depressions south of the equator, the western disturbances give a good distribution of rain in N.W. India, occasionally reminding one of a 'monsoon day'. If there be a tropical cyclonic storm or a depression south of the equator (but not too far south) in the Indian Ocean, the lower secondaries of the western disturbances are either not formed or at best ill-defined over N.W. India and produce scanty rain.[6] The winter rain in N.W. India should be negatively indicated with the monsoon in S. Indian Ocean and hence negatively correlated with the North American pressure with the necessary time lag. This was an important point that could be checked.

To get as representative a value of the pressure as possible over the high pressure area of the south and west high of the U.S.A., the mean pressure of four stations was taken : Portland (Oregon), St. Louis (Mis.), Galveston (Texas) and San Diego (Cal..), for the period 1876-1930. The pressure for October and November was correlated with rain over N.W. in the succeeding January to March period (the rain in December is small). The value of

C.C. of North America South and Western portions (Oct.+Nov.) Pressure to N.W. India rain in succeeding Jan. to March was —0.38, the Probable error being 0·09.

The other important question that arises is the relation between the north-east portion and the winter high over America and the Indian weather. This portion would give rise to westerly winds. It is well known that this region is the starting point of the Atlantic depressions that affect the temperate latitudes, or the extra-tropical depressions one of whose successive secondaries affect India in the winter. A high pressure area over the north-east portion of the high over N. America in winter should help in the formation of extra-tropical depressions and hence in the formation of secondaries that affect India. Other things being equal more secondaries would mean more rain in N.W. India. Hence the rain in N.W. India should be positively correlated with the pressure in the north-east portion of the winter high over N. America. As the speed of the westerlies in temperate latitudes is much greater than the easterlies in the equatorial latitudes, the time lag between N. America and N.W. India would be about 15-20 days only. Hence the contemporary correlation coefficient would have to be tried if a period of about three months is taken for rain. The stations that were chosen to represent pressure were Chicago, Albany (N.Y.) and Washington.

C.C. of North America (N.E. Portion) Jan. to March pressure to contemporary rain in N.W. India was 0.194 for the same number of years (1876-1930). This is significant to 80% level.

(The correlation coefficients were calculated by Mr. K. S. Ramamurthy for me.)

It is interesting to notice the behaviour of different portions of the North American winter high towards rain in N.W. India. If the North American high pressure area remained abnormally high throughout the southern winter, it follows that due to the souhern and western portions of it, the winter rain in N.W. India should be defective and due to the influence of the north-east portion of the high pressure the rain in N.W. India should be abundant. Different portions of the same high pressure area exercise opposing influences. In other words, the high pressre area acts as a sort of balancing factor to N.W. India rain. The passage of western disturbances from west to east would pull the 'pulses' or low pressure areas travelling in lower latitudes and may occasionally prevent their crossing of the equator and may create a "break" in the monsoon in the southern hemisphere. Or the high pressure area may also act to a certain extent as a balancing factor for the southern monsoon also.

It appears probable that even for the Indian monsoon, one portion of the southern high near S. America may give rise to 'pulses' moving westwards and ultimately producing the S.W. monsoon in India. A more southerly portion of the high may give rise to extra-tropical depressions, which travel in the southern hemisphere from west to east, may pull down the monsoon pulses and create a "break" in the Indian monsoon.

The high pressure belts away from the equator on either side of it seem to act as stabilising factors on the weather on the two sides of the equator, one being more prominent in northern summer and the other in southern summer.

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1. *Forecasting Weather in and Near India.* S. L. Malurkar. Printed limited number in May 1944, pp. 34. 2. *Ibid.*, 119. 3. *Ibid.*, p. 87. 4. *Ibid.*, p. 120, *et seq.* 5. *Ibid.*, p. 101. 6. *Ibid.*, p. 105.

RAINIEST SPOT IN THE WORLD

By H. L. CHHIBBER

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IT was surprising to observe that even the standard books on climatology gave varying data about the rainiest place in the world. H. F. Blanford in his book on *The Climates and Weather of India, Ceylon and Burma*[1] (p. 73), has given the average monthly and total annual rainfall of Cherrapunji as follows:—

W. G. Kendrew in his book on *The Climate of the Continents*[2] (p. 55), has stated that "the west side of Kamerun Peak has 412 inches *per annum* near sea-level, the second highest record in the world, surpassed only at Cherrapunji (India) which has 458 inches", while on p. 131 of the same book 428 inches is given as the annual mean rainfall for Cherrapunji.

Elevation in feet	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov	Dec.	Total
4,455	0·6	2·6	9·0	29·6	50·0	110·0	120·5	78·9	57·1	13·6	1·8	0·3	474·0

The monthly average of rainy days on p. 74 is given below:—

Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total
2	4	10	20	25	26	29	28	24	12	3	1	184

Referring to p. 222 of the same treatise the following figures are given for the mean rainfall of Cherrapunji.

Cherrapunji	Altitude in feet	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	4,309	0·7	2·1	11·7	30·8	46·2	96·8	98·2	76·5	46·1	16·7	1·9	0·2	427·9

The same author in his book on *Climate*[3] (p. 141), has stated: "The very high mean of 412 inches is recorded near sea-level on the south-west side of Kamerun Peak, where a south-west wind blows on-shore for the greater part of the year, and there is certainly much more on the higher slopes; the heaviest rains are from June to October, the months when the monsoonal indraft is strongest. Kamerun is situated about 5° N. lat. and this too tends to give it its wettest season in the northern summer. There are stations outside the equatorial belt which have a large rainfall." On pp. 39-40 of *Climatology*,[4] by Austen Miller, it is recorded: "the heaviest rainfalls in the world are recorded under such conditions, Kauai[1] in the Hawaiian Island, has an average rainfall of 476 inches and *Cherrapunji, in Assam, has* 450 *inches.*

In the same connection, W. G. Kendrew in his book on *Climate*, has recorded on p. 145[2]: "the north-east trades of the Pacific Ocean meet such a barrier in the Sandwich Islands, while the volcanic mountains rise steeply from the Ocean to 13,000 feet; on Mount Waialeale (5,080 feet) in the Island of Kauai a high cliff facing north-east forces the Trade winds to rise almost vertically, and the rainfall is both heavy and continuous. The records are *slightly uncertain* owing to the difficulties involved in reaching this remote and elevated spot in order to reach the rain-gauges, but it seems that the mean daily rainfall is over 1 inch and the annual mean over 400 inches. This is among the highest figures recorded on the earth."

Finding such great discrepancies in standard works on climatology, it was deemed advisable to refer the matter to the India Meteorological Department since relevant references were not available at Benares. The Dy. Director-General of Observatories, Poona, informed me that there are at present three rain-gauges at Cherrapunji with annual total rainfall as tabulated below:—

CHERRAPUNJI RAINFALL
(*Average Annual Total*)

I. *Provincial rain-gauge, located in the Police Station* (started in 1871):
   (1) From Blanford's. This average is based on data before 1899—474".
   (2) From 'Rainfall of India', *Memoirs*, Vol. No. XIV. Average based on data from 1872 to 1900. (This publication appeared in 1902)—457"·8.
   (3) 1920 normal. Based on data upto 1920 (49 years)—427"·8.
   (4) 1940 normal (70 years)—425"·5.

II. *Rain-gauge at Cherrapunji Welsh Mission House* (opened in 1903):
   Average 1903-1920 (18 years)—441"·7.
   1940 normal (38 years)—459"·6.

III. *Rain-gauge at Cherrapunji Observatory* (opened in 1906):
   1940 normal (35 years)—425"·2.

Monthly and Annual Rainfall (in Inches)

Station	Lat °N	Long.	Height	Length of record yrs.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Cherrapunji (Police Station) Provincial rain-gauge	25°16′	91°44′E	4,309	70	0·73	1·91	9·92	28·80	49·82	100·35	93·85	73·11	45·95	16·74	2·06	0·22	425·46
Cherrapunji (Welsh Mission House)	25°16′	91°44′E	4,309 Approx	38	0·86	2·28	7·58	28·61	52·67	114·71	106·04	76·61	44·59	21·66	3·59	0·59	459·59
Cherrapunji (Observatory)	25°16′	91°44′E	4,309	35	0·75	2·11	7·27	26·23	50·44	106·05	96·24	70·08	43·35	19·42	2·70	0·49	425·23
Waialeale (Kauai Is.)	22°4′	159°30′ W	5,075	20	*	*	*	*	*	*	*	*	*	*	*	*	460 20
Debundja (Nigeria)	4°5′	8°59′E	16	14	7·91	11·26	16·06	18·11	25·43	58·35	63 03	54·21	61·42	46·34	24·06	13·39	399·57

Note.—Not available. Data of 4 and 5 taken from *Climate and Man*, published by the United States Department of Agriculture.

In the above table are given the monthly and annual rainfall figures for the three rain-guages in Cherrapunji along with its co-ordinates, height above sea-level and the length of record. The same figures for Waialeale in Kauai Island (as far as available) and Debundja in Nigeria are also tabulated.

Waialeale, Kauai Island, Hawaii territory, according to data in *Climate and Man*, a publication of the United States Department of Agriculture, has an average annual total rainfall of 460 inches. No monthly figures are available and the average is based on data of 20 years only. This average, however, is not supported by the data of annual rainfall for the years 1912 to 1930, given in *Heavy Rainfall Records*, by Jhon R. Theman. The figures for Waialeale are reproduced in the table in the previous column.

MT. WAIALEALE (Hawaii Territory)

Year	Rainfall in inches
1912 ..	414·00
1913 ..	451·00
1914 ..	—
1915 ..	—
1916 ..	521·00
1917 ..	—
1918 ..	—
1919 ..	204·00
1920 ..	549·00
1921 ..	367·00
1922 ..	452·00
1923 ..	360·00
1924† ..	228·00
1924–25* ..	362·40
1925–26* ..	219·60
1926–27* ..	405·24
1927–28* ..	—
1928–29* ..	354·22
1929–30* ..	301·95

* From July 1 to July 1.

† Records of six months.

In view of the foregoing and also the much longer period of 38 years on which the average of the rainfall at the Welsh Mission House, Cherrapunji, is based, it may be taken that the rainfall of Cherrapunji is higher than that of Waialeale.

With regard to other places having high rainfall it may be noted that Mawsynram, a station near Cherrapunji, has records of a few years which show that it has a rainfall of well over 400 inches. No average is given as the period of data is short.

The only other station known, which has an annual rainfall of 400 inches or over is Debundja in Nigeria. Its average annual rainfall based on data of fourteen years only is 400 inches.

From the above it appears that Cherrapunji receives the heaviest rainfall in the world. Next to Cherrapunji and Mawsynram, the places of heaviest rainfall seem to be Waialeale and Debundja.

I wish to express my great indebtedness to the Deputy Director-General of Observatories, India Meteorological Department, for kindly helping in elucidating this important matter.

1. Blanford, H. F., *A Practical Guide to the Climates and Weather of India, Ceylon and Burma* (MacMillan), 1889. 2. Kendrew, W. G., *The Climates of the Continents* (Oxford University Press), Third Edition, 1941. 3. Kendrew, W. G., *Climate* (Oxford University Press), 1942. 4. Miller, A. Austen, *Climatology* (Metheun), Fourth Edition, 1946.

NEW METHODS OF PRODUCING HIGH ENERGY PARTICLES

By G. SURYAN and C. K. SUNDARACHAR

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THE extension of our knowledge in respect of the meson and the short-range forces inside the atomic nucleus awaits the development of laboratory techniques accelerating charged particles to cosmic-ray energies. The relativistic increase in mass leading to a change in frequency sets an upper limit to the energy of a well-defined beam of ions in the cyclotron. Devices which give promise of attaining energies in excess of 200 Mev. are the (1) betatron, (2) synchrotron, (3) relativistic cyclotron, (4) microtron, (5) linear resonance accelerator and (6) linear wave guide accelerator. The first four bring about resonance acceleration in a steady or varying magnetic field and the last two make use of micro-waves.

The induction electron accelerator called the *betatron* was perfected by Kerst.[1] A stream of electrons shot tangentially into a toroidal vacuum chamber placed between the pole-pieces of an A.C.-fed electromagnet gets accelerated in the electric field induced by the changing magnetic field. Decrease of the field with the radius gives rise to magnetic focussing, resulting in a fine output beam. The magnet of the 100 Mev. betatron built by the G.E. Co. at Schenectady weighs 130 tons, has a pole-face of 16 inch diam., and is fed by a 60 cycle A.C. at a full load of 200 KW. Although it may be possible to raise the energy to 500 Mev. by proper adjustment of the time dependance of the field, the loss of energy by radiation will be considerable at the higher energies.

The *synchrotron* due to Veksler[2] and McMillan[3] uses a time-varying magnetic field as in the betatron and a split thin-walled dee system connected to a high voltage generator as in the cyclotron. The inherent phase stability of the orbits brings about automatic synchronisation and makes up for moderate energy losses. When accelerating heavy particles, the damping of the phase oscillation set up by the radial displacement of the orbit may be compensated by motor-driven tuning devices. If the radiation loss per turn can be reduced in respect of the amplitude of the dee voltage,

1000 Mev. energies may possibly be reached. The Metropolitan-Vickers have under construction a 300 Mev. electron synchrotron and the Birmingham University a proton synchrotron.

Relativistic cyclotrons producing ions of energy more than 200 Mev. can be constructed if the problem of space and time variation of the magnetic field are solved satisfactorily. Arrangements are in progress to convert the 184-inch Berkeley cyclotron into a frequency modulated instrument (synchrotron cyclotron). It is expected that a dee voltage of only 50 kV. will be able to generate one micro-ampere of 200 Mev. deuterons.[4]

The *microtron* is an electron cyclotron where the particles are made to slip one cycle of phase in each circuit. A micro-wave resonator located near the edge of a uniform magnetic field gives rise to the necessary electric field. The use of a split magnet and several resonant cavities in series worked by a single power source is suggestd by Schwinger to compensate for the drift in the orbits. The short acceleration time of the electrons makes the radiation loss negligible and the large separation of the orbits facilitates the easy removal of the output beam. Electrons of 1000 Mev. energy can be produced if defocussing can be counteracted by proper shaping of the magnetic field or by the insertion of a loosely coupled parallel series of resonators.

The *linear resonance accelerator* uses an array of high Q resonators operated at a metre wave-length and pulsed simultaneously. When used for accelerating ions, a loosely coupled coaxial line, driven by a master oscillator and loaded suitably, may be employed to phase the system. Radiation losses are at a minimum and the equipment is inexpensive compared to the magnetic devices. A 450-metre long system may be needed to generate 300 Mev. electrons. The *linear wave guide accelerator* developed in the M.I.T. Radiation Laboratory consists of an array of tightly coupled resonators operated from a single oscillator. If difficulties connected with the accurate construction of wave guide sections to avoid the propagation of unwanted modes and the provision of an automatic tuning to overcome temperature and other variations are successfully tackled, it may be possible to speed up electrons to 1000 Mev. energy. A detailed discussion of the working and possibilities of the new devices is given by Schiff.[5]

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WHAT IS MASS?

By D. FERROLI, S.J., D.Sc.

1. *Tentative Definition.*

IN text-books which are very widely used, we find the mass of a body defined as "the quantity of matter it contains".

Matter is tentatively defined as "that which can be perceived by the senses" (*confr.* Loney, *Dynamics of a Particle*, pp. 4-5).

Hence, colour, sound, electricity, magnetism would presumably come under the *genus* "Matter". I wonder whether many would agree to this. Another definition is: "Matter is that which can be acted upon by, or exert force".

So matter would be both active and passive, under different circumstances. Could perhaps, matter, under its active aspect ("that which can exert force") be identified with energy?

The author in question is aware of the imperfection of his definition, for he adds: "Matter, like time and space, is a primary conception, and hence it is practically impossible to give it a precise definition".

2. *Mass under a triple aspect.*

As the student advances, he meets the concept of mass under three aspects:

(*a*) From the first fundamental equation of Dynamics: Force = Mass × Acceleration, one would deduce that mass is a *coefficient of inertia*, it is something passive, something which, in a way, tends to resist acceleration.

(*b*) In the second fundamental equation of Dynamics: Mass × Velocity = Acceleration × Time, the mass assumes a slightly different connotation; it is a *capacity of impulse*, it is something which contributes to the momentum of a body. The contribution, however, does not seem merely passive, but active, as a man who tries to stop a roller or a cricket ball, would experience.

(*c*) Finally in the equation of energy E = Half the mass by the square of velocity, the mass is a capacity of *kinetic energy*—not energy really, but something that can be energised, invested, so to say, with energy. The passive aspect of mass is again prominent.

3. *Mass in Relativistic Mechanics.*

In Relativistic Mechanics the above three definitions of mass do not give the same values. In fact, even before Einstein, one met in Higher Mechanics the Maupertuisian Mass, the Hamiltonian Mass and the Leibnitzian Mass.*

The present writer has dealt at length with their conceptual significance in his *Madras University Lectures* (March 1927), which were published by the University in 1929. Here it may be sufficient to point out that:

(*a*) If mass is a *coefficient of inertia* then it is necessary to consider two masses: *the longitudinal* mass, when the force is parallel to the velocity; and the *transversal mass*, when the force is

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* Of which the Maupertuisian mass is the mean of the Hamiltonian and the Leibnitzian masses.

perpendicular to the direction of the velocity.

Both vary with the velocity, but according to different laws. They are equal when the velocity is zero.

(b) If mass is considered as *a coefficient of impulse*, then there is only the transversal mass, which is independent of the direction of the force.

4. *A Query.*

Now it may be asked: If a different direction of force leads to a different conception of mass, are the respective formulæ merely a result of different definitions of time and space, or do they point to a different and real configuration of the particles constituting the mass in question? For it is conceivable that a different configuration may afford a different reaction, according as the force is parallel, or perpendicular to the velocity. Now is the different configuration produced gradually or instantaneously? And if gradually, what would be the mass when the force is in a direction which is neither along, nor perpendicular to the direction of motion? A solution which is based on the parallelogram law seems unsuitable, for in Relativistic Mechanics, velocities are not compounded according to the parallelogram law.

5. *Classical Definition of Mass is discarded.*

It is clear, however, that the classical conception of mass, as a definite quantity of matter in a body, is thrown overboard. Similarly the idea is abandoned that mass is something which remains constant throughout all the transformations of matter; on the contrary, mass varies with the velocity of matter.

But one may reasonably ask the meaning of these words "mass varies with the velocity of matter", when matter has been emptied of what seemed to be its most fundamental attribute—that of mass and inertia. In fact, if mass varies, can we say that matter changes at all? Or, if it changes, what is it that remains constant throughout the change? For a change which is all change, without anything that really changes is difficult to conceive. Or have we, perhaps, to go back to Aristotle's *"prote ule"* which is the same throughout all changes, not being liable to "corruption and generation"?

6. *Is Matter also to go overboard?*

H. Poincare begins his most suggestive chapter on *"La fin de la matiere"* with the words: "L'une des découvertes les plus étonnantes que les physiciens aient annoncées, c' est que *la matiére n' existe pas"*. And yet is there not a way of saving the existence of matter?

In the theory of the cathode corpuscles, unchanging mass still leaves its traces quite discernible, though it is almost nil in comparison with the electro-magnetic mass which is revealed by the phenomenon of *self-induction*. But in Einstein's conception an unchanging mass finds no place whatever. Again, the negative corpuscles, though apparently endowed with inertia, borrow it entirely from the æther, whilst, according to Einstein, the inertia of a moving body is inherent in the body, though it changes with the directed velocity of the body itself, and has nothing to do with the æther, for the æther, itself is done away with. According to Lorentz, matter has no existence, and what we call matter is but a hole in the æther. For M. Langévin, matter is only liquid æther, which has lost its properties. Matter in motion is not liquid æther moving through ordinary æther, but it is merely an extension or propagation of liquefaction, the æther gradually melting in one direction and solidifying in the direction opposite to the direction of motion. Hence moving matter would constantly lose its identity.

Einstein does away with these interesting suggestions; for him matter is but a mathematical function with the power of reaction on a fourfold geometrical variety, which may be called the *time-space* or the *chronotope*.

7. *The Kingdom of Nominalism.*

But is this modern tendency to change everything into mathematical formulæ a healthy one? Mathematicians think they simplify things. Rather than simplifying them, they etherialize them into the purest gossamer. In the XVI century a reaction set in against the hair-splitting exaggerations of the later scholastics. It was a healthy reaction: the reaction of Induction against exaggerated Deduction, the reaction of observation against abstractions, the reaction of objective against subjective science. Now abstractions have come back—no less insidious, because dressed in a mathematical garb, Nominalism seems again to have taken its seat among scientists. It is true that mathematics deals with *symbols*, but its symbols must be capable of some interpretation. Now, what is the interpretation to be given to *mass*? and if *mass* cannot be interpreted apart from matter, what is the interpretation to be given to *matter*? ... One does not want to be flippant, but *Punch's* joke seems appropriate: "What is matter? Never mind". "What is mind? No matter".

Or perhaps Bertrand Russell's paradox: "Mathematics is the science in which we do not know what we are talking about, and do not care whether what we say about it is true."

Science seems to have turned full circle. Descartes was satisfied with the truth of a statement only if it could be given a mathematical expression. Aristotle maintains that *"In mathematicis non est bonum"*. No good in mathematics ..... or is it in the mathematicians? .....

THE CILIATE MACRONUCLEUS

By B. R. SESHACHAR and K. V. SRINATH

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IT is now fairly clear that so far as staining reactions are an indication, the ciliate macronucleus contains a large amount of desoxyribose nucleic acid.[1] This is a matter of major significance, for it has been known for a long time that no chromosomes are formed in it during division, which is of the amitotic type. The occurrence, therefore, of a large quantity of desoxyribose nucleic acid in a nucleus which admittedly does not form chromosomes deserves an explanation; for in other organisms, this has been seen to occur only in association with the chromosomes.

Chromosomes have, however, been reported to be formed in the macronucleus of *Tetrahymena galeii* by Painter[2] and earlier by Hegner and Holmes[3] in *Balantidium*. But these would appear to be exceptions; for normally the division of the ciliate macronucleus is by the direct amitotic type, without chromosome formation. In species of *Epistylis* with which the authors are particularly well acquainted, it is indisputably so.

The occurrence of desoxyribose nucleic acid in the ciliate macronucleus leads one to conclude that it exists there in a condition and relationship very different from those in which it is present in the metazoan nucleus. Recent work[4] on the behaviour of the nucleus in mitosis has shown that the polymerization of the nucleotides is dependent on the protein framework of the chromosome. In fact, the chromosome thread (protein) controls the polymerization of its thymonucleic acid charge, and if the chromosomes are not formed in the ciliate macronucleus, it is more than likely that the reason lies in the extent or nature of its protein content. This in turn is related with the reproduction of the thread, and so the division of the nucleus itself. It is clear, therefore, that the whole chain of events and reactions of mitosis hinge on this central fact of the protein content of the nucleus; and if, in spite of the presence of one of the essential constituents of the chromosome, i.e., desoxyribose nucleic acid, the chromosomes are not formed by the macronucleus, it is clear that the other constituent, i.e., protein, is in some way deficient. In fact, one is led to the possibility of visualising the ciliate macronucleus as a body which is either partially or completely lacking in protein, and that that is responsible for the non-formation of the chromosomes by it, and in turn, for its amitotic division.

If it is true that the desoxyribose nucleotides occur in the macronucleus in an unpolymerized condition and unrelated to protein, then this would offer the first instance, unique among animals, where desoxyribose nucleic acid exists outside of and dissociated from the chromosome thread. But it is also significant that almost alone among normal nuclei of animals, the macronucleus of the ciliate is the one that unquestionably divides by amitosis.

The growth and reproduction of the macronucleus offer other interesting points. Whatever the condition in *Tetrahymena*,[2] the macronucleus of most ciliates, and particularly of *Epistylis*, divides at every binary fission, by a simple process of constriction, and each daughter individual has a macronucleus much smaller than that of the parent. This means, a period of growth must follow binary fission during which the macronucleus must enlarge. Growth of the macronucleus must involve the addition of material to it, which we have seen, is largely desoxyribose nucleic acid. It can come from one of two sources. The existing nucleotides in the macronucleus of the daughter individual must reproduce; or new nucleotides, manufactured in the cytoplasm, must find their entry into the nucleus through the nuclear membrane. In the one case it would be a multiplication of desoxyribose nucleotides within the nuclear membrane; in the other, the ribose nucleotides, manufactured in the cytoplasm, must get converted into those of the desoxyribose type on their entry into the nucleus.

If the former possibility is admitted, it will provide the first instance of the multiplication of desoxyribose nucleotides outside the protein medium of the chromosome, where only they are known to do so. This, however, is not surprising, for nucleic acid has been shown[5] to possess the inherent property of self-multiplication.

The second possibility is full of interest. That cytoplasmic nucleotides occur in a variety of animal cells is now fairly well known. That they contribute to the nucleic acid content of the chromosome at mitosis is also clear, and evidences have been presented for a transference of cytoplasmic nucleotides into the nucleus at every mitotic cycle, through the nuclear membrane during early prophase, and more especially at pro-metaphase, when by the breaking down of the nuclear membrane, the cytoplasmic and nuclear materials are in confluence. So it is not surprising that ribose nucleotides pass after every binary fission into the macronucleus, become converted into those of the desoxyribose type and so augment the nucleic acid content of the macronucleus. But it is significant that a situation analogous to pro-metaphase occurs at no time in the history of the ciliate macronucleus, for never does it lose its nuclear membrane, nor does its material ever come in direct and open communication with the cytoplasm. Hence, if cytoplasmic nucleotides pass into the nucleus, they must do so through the nuclear membrane. Painter[2] has recently reported the presence of large quantities of ribose nucleotides in the cytoplasm of ciliates, and the formation of macronuclear buds and their disorganization in the cytoplasm[2,6] must release large quantities of nucleic acid there. These would find their way back, ultimately, into the nucleus at the time of its growth.

There is still a final point to which we would refer, i.e., the origin of amitosis of the

macronucleus. It is to be assumed that in a normal nucleus capable of mitosis, a definite protein-nucleic acid ratio exists, and should be maintained. It is only on the basis of this assumption that the interaction between these two substances makes mitosis possible. Quantitative studies have shown that the chromosome which is more or less entirely a nucleoprotein, contains a 40 : 60 ratio of nucleic acid and protein.[7] Therefore it would seem necessary that a certain basic protein equipment would be required for the building of a chromosome. Any disturbance of this protein-nucleic acid ratio must have a deterrent effect on mitosis and must produce a condition when mitosis does not occur at all or is so disturbed that it degenerates into amitosis. On this view we may find an answer to the behaviour of the ciliate macronucleus. Of the two substances which alone are known to form the chromosomes, one of them, i.e., desoxyribose nucleic acid, is present in it. And yet no chromosomes are formed. The reason probably is, as set out earlier, the protein-nucleic acid ratio has been upset, with the result that the chromosomes are not formed, and no mitosis occurs.

Why and how this ratio is upset may now be briefly examined. The behaviour of the conjugating ciliate immediately after syngamy appears to provide an answer. The synkaryon is capable of mitosis and divides a number of times. A distribution of the resulting nuclei among the daughter individuals takes place so that each comes to possess the normal nuclear equipment. Concomitant with this is the enlargement of some of the nuclei to become the macronuclei, while the others that do not enlarge, remain as the micronuclei. It is significant that the nuclei which do not enlarge retain the faculty for mitotic division, while those that do, lose it.

We would regard this enlargement as a process of acquisition of cytoplasmic nucleotides. On this basis, it is clear that against a known and fixed protein equipment of the original small nucleus, the addition of enormous quantities of nucleotides has so overloaded it with nucleic acid that the functional ratio between it and the protein has been upset, with the result that the macronucleus has been dispossessed of its vital attributes of chromosome formation and mitosis.

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VITAMIN A IN FISH LIVER OILS AND CAROTENE IN FOODSTUFFS

By A. R. SUNDARARAJAN

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THE vitamin A activity of some fish oils and foodstuffs has been reported previously from these Laboratories.[1–9] It was observed that the liver oils of some of the fishes that abound the waters along the coast of India are much richer in vitamin A than Norwegian cod liver oils. A number of fish oils has since been assayed for vitamin A and this paper embodies the results of such assays. The non-saponifiable fractions of the oils were used for the assays. The method adopted was either tintometric or spectrographic or both and was the same as described by Rajagopal.[7] The factor adopted for conversion of Carr-Price value of the oils into International Units of vitamin A per gramme was 53.

Some samples of foodstuffs and carotene concentrates were assayed for their carotene content by the tintometric method as described by Sekhon.[8]

Results

TABLE I

Vitamin A content of shark liver oils estimated by the tintometric and spectrographic methods

Source	C. P. valueon non-sap	Vitamin A. I.U./g (by the spectrographic method)	I.U. of vitamin A/g (Spectrograph method)
			C.P. value on non-sap.
(1)	(2)	(3)	(4)
Calicut	1.003	46.550	46·4
do.	839	36,510	43·6
do.	551	28 490	51·7
do.	577	27.500	47·7
do.	382	20,640	54·2
do.	272	15,140	55·7
do.	239	14,940	62·6
do.	298	14,910	50·1
do.	291	14 000	48·1
do.	107	6,860	64·2
do.	117	6,000	51·3
do.	56	2,780	49·8
do.	37	1,780	48·0
Ceylon	164	7,890	48·0
do.	69	3,870	56·2
Average	319	16 524	51·8

TABLE II. *Vitamin A content of shark liver oils estimated by the tintometric method*

Source	No. of Samples	Vitamin A in I.U. per g.		
		Max.	Min.	Average
Alleppey ..	2	16,250	6,900	11,575
Baroda ..	1	4,000	4,000	4,000
Bombay ..	2	11,370	7,700	9,535
Calicut ..	4	12,780	6,250	8,428
Ceylon ..	7	7,400	1,180	2,736
Karachi ..	19	37,900	1,470	9,829
Trivandrum ..	17	18 500	1,090	8,533
Average ..	52	37,900	1,090	8,287

TABLE III. *Vitamin A content of blended fish liver oils appearing on the market as substitute for cod liver oil*

Source	No. of Samples	Vitamin A in I.U. per g.		
		Max.	Min.	Average
Bombay ..	4	2,400	1,360	1,743
Calicut ..	7	1,600	700	1,251
Ceylon ..	2	1,680	1,000	1,340
Karachi ..	5	1,300	400	369
Kolhapur ..	1	1,140	1,140	1,140
Madras ..	13	1,200	76	396
Average ..	32	2,400	76	872

will be useful for infants and invalids who are unable to tolerate large doses of oil.

Table III indicates the desirability of having proper legislation to protect the interests of the consumer. Of the 32 samples assayed, only 15 were found to have a value of 1,000 or more I.U. of vitamin A per gramme. Hence it is essential that the law should insist that the vitamin A content of oils put on the market as substitutes for cod liver oil should have a minimum potency of 1,000 I.U. per gramme (B.P. standard).

It should be borne in mind that it is only the red carrot that is rich in carotene; the white and violet varieties are very poor in this constituent (Table IV).

SUMMARY

1. Sixty-seven samples of shark liver oils, obtained from various parts of India, were found to have an average vitamin A potency of 10,130 I.U. per gramme. It is concluded that a 'high potency' shark liver oil (10,000 I.U. per g.) can be placed on the market involving little effort.

2. Thirty-two samples of 'blended' fish liver oils had, on an average, 870 I.U. of vitamin A per g. The importance of enforcing standardization of vitamin A products by legislation is emphasized.

3. The carotene content of a few foodstuffs and concentrates is reported.

TABLE IV. *Carotene content of foodstuffs, red palm oils and concentrates*

	Botanical name	Source	Carotene content in μg. per g.
Carotene concentrate (3 samples) ..	—	Bombay	47,360
,, crystals (prepared from grass) ..	—	Calcutta	24,540
,, concentrate ..		Bombay	17,400
,, ,, (type 150°) (4 samples) ..	—	,,	12,600
Red palm oil (2 samples) ..	*Elais guineensis*	Manmad	600
,, (4 samples) ..	do.	Travancore	440
Amaranth, green ..	*Amaranthus gangeticus*	Coimbatore	120
do., red	do.	,,	105
do., spiny	*A. spinosus*	,,	101
do., Kangoon	*Amaranthus gangeticus*	,,	77
Carrot, red	*Daucus carota*	Ootacamund	105
do., violet	do.	,,	8·4
do., white	do.	,,	1·3
Palm fruit, juice	*Borassus flabellifer*	Cochin	33·8
Margarine (4 samples)	—	Bombay	9·3
Red gram, red	*Cajanus indicus*	Central Provinces	0·9
do., white	do.	,,	0·9
Spent yeast	—	Bihar	0·8
Cashew nut oil	*Anacardium occidentale*	Coimbatore	0·8
Soya bean milk	*Glycine hispida*	—	0·4
White ragi	*Eleusine coracana*	—	0·1
"Bel Vita" (a marmite substitute) ..	—	Bihar	Trace
Vanaspati (12 brands) ..	—	Sind	Nil

DISCUSSION

It will be seen from Tables I and II that most shark liver oils are very rich in vitamin A. Similar high values have been recorded for Indian fish liver oils by workers in other laboratories.[10–14] Column 4 of Table I indicates that the conversion factor 53, used for conversion of Carr-Price value into International Units per gramme, is justified. The average value for vitamin A assayed is of the order of 10,000 I.U. per gramme. Hence, merely by mixing of the oils, shark liver oil of this potency can be placed on the market which

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STATISTICAL METHODS IN PLANT AND ANIMAL BREEDING

A SYMPOSIUM on the application of Statistical methods to plant and animal breeding was held on the 26th and 27th December 1946, under the joint auspices of the Indian and National Academies of Sciences during their annual session at Allahabad.

Dr. Panse (Indore), who opened the discussion, dealt with the importance of plant breeding as a means of producing better crops without the need of any extra expenditure on the part of the cultivator. Considerable progress had been made in the past with this method of improvement and improved varieties of sugarcane, rice, wheat and cotton were already being grown on a fairly large acreage; but the plant breeder had still to cover a wide field, and in order that he should do his task efficiently, an increasing application of statistical methods to plant breeding was essential. Dr. Panse then considered the various problems that a plant breeder is confronted with in the initial choice of suitable material for selection, the process of selection in this material, and the maintenance of improved strains evolved as a result of selection. He pointed out that there were two criteria for the choice of material suitable for selection, namely, mean values and genetic variability. He illustrated with the help of data from a cotton-breeding experiment carried out at Indore, how these criteria could be measured and used. The superiority of the progeny-row technique on mass selection was in his view an essentially statistical argument. He then explained how statistical method could be profitably employed by the plant breeder at the different stages of his work thereby increasing his chances of success.

Dr. Sukhatme (Delhi) discussed the use of statistical methods in the field of animal breeding. He pointed out that animal breeding had lagged far behind plant breeding in the use of statistical methods, and illustrated, by means of data of an animal breeding project, how, owing to the lack of proper planning and statistical examination of the results obtained during the course of the project, it was discovered, after a period of ten years during which the scheme was in progress, that no real improvement was achieved. He explained how this conclusion was established clearly by a critical examination of the full results of the scheme with the help of statistical methods. While he felt that experimental techniques based on statistical principles had a more limited scope in animal breeding as compared to plant breeding, he emphasised the need for a careful examination of the progress of an animal breeding programme from the beginning by the use of appropriate statistical methods.

Dr. Ramdas (Poona) pointed out the meteorological aspect in plant breeding and explained how drought-resistance of crop varieties could be tested in glass houses under controlled humidity and temperature.

Mr. Koshal (Poona) discussed the statistical analysis of F_1 data for obtaining information of genetic interest with the illustration of fibre characters in three crosses between Cwn. 520, Bani and Malvi strains of cotton. He pointed out the need of randomised replicated trials right from the beginning of selection. Otherwise the breeder is often misled into selecting material on the basis of non-genetic variation and such selection proved futile when progenies are grown from the selected plants.

Mr. Kishen (Lucknow) explained the use of discriminant function for plant breeding. He also emphasised the need for randomised and replicated trials and suggested the use of modern incomplete block designs in plant breeding. He then considered the possibility of using similar designs in trials with animals.

Mr. Bokil (Indore) considered theoretically the relationship between hybrid vigour and F_2 and F_3 variances and gave their expected values for a variety of genetic hypotheses. Referring to Dr. Panse's suggestion that selection in F_1 is worth considering, he pointed out that the F_1 mean appeared a safe guide for selection generally on account of the fact that in none of the genetic cases he had considered, a larger variance in F_2 resulted from a lower F_1 mean.

Mr. Sahasrabuddhe (Indore) compared the efficiencies of various incomplete block designs against ordinary randomised blocks with special reference to cotton breeding with the help of data from a uniformity trial. He stated that his conclusion was that the simple randomized block layout was quite efficient for as many as 125-150 progeny plots of 5 to 10 feet long per block arranged compactly.

Mr. Thawani (Delhi) explained the principle of discriminant function and its use in plant selection. He referred to possible extensions of the simple linear functions that have been recommended.

Among other speakers that took part in the discussion, Dr. Chandrasekhar (Calcutta) stated that the statistical method was the only possible approach to the study of human genetics.

Mr. Ramiah (Cuttack), who summed up the discussion, agreed with the view that a close co-operation between the breeder and the statistician was necessary. The progress already made in this direction was, in his opinion, satisfactory, and he hoped with confidence that statistical methods will play an increasingly useful role in the work of crop and animal improvement in India.

NEW SCHEMES OF THE COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, INDIA

A sum of about Rs. 5·5 lakhs has been sanctioned for continuing the work on various research schemes in Universities and Research Institutions. Some of the new schemes that have been sanctioned are, development of high purity manganese, manufacture of Beryllium and its alloys, investigations on rare earth minerals, study of industrial wastes as supplemental sources of nitrogen and vitamins, investigations on micro-waves from extra-territorial sources and on Raman spectra of organic compounds.

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ELECTROLYTIC REACTIONS ON POROUS CARBON ANODES—PART I: The Preparation of *P*-Benzoquinone by the Oxidation of Benzene

p-Benzoquinone is largely used in the dye-stuff industry, in the preparation of hydroquinone, and in many processes of synthetic organic chemistry. It is mostly prepared by the oxidation of aniline by chromic acid. Its electrolytic preparation was attempted by Inoue and Shikata[1] who used lead peroxide as anode, and claimed a current efficiency of 81·5 per cent. Their results could not be confirmed by Seyewetz and Miodon[2] who obtained under identical conditions a current efficiency not exceeding 26 per cent. The latter workers obtained a current efficiency of 65 per cent., using lead peroxide as anode, and a bath containing 25 per cent. H_2SO_4, 33 per cent. CH_3COOH and 1·5 per cent. $PbSO_4$. The method, however, has not found any use in industry.

The advantages of using a thick-walled porous carbon tube closed at the bottom as anode are the following:—

(1) It is cheap and chemically inert under ordinary current densities.
(2) Catalytic materials which help anodic reactions can be easily deposited on the pores.
(3) It can function as a wick for the passage of benzene through the pores to the active surface of the anode and thus eliminate the need for vigorous stirring which is essential for high yields of *p*-benzoquinone according to Seyewetz, *et al.*

Thick-walled porous carbon tubes were soaked in solutions having different concentrations of potassium ferricyanide, taken out from the bath and the adhering solution wiped off. The tubes were then dried in an oven, and used as anodes. The electrolytic bath was composed of 2 per cent. sulphuric acid containing as catalyst, potassium ferricyanide of the same concentration as was used for impregnating the carbon anode.

Under certain conditions, a current efficiency of 51 per cent. in the electrolytic conversion of benzene to *p*-benzoquinone has been obtained.

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1. Inoue and Shikata, *J. Chem. Ind. Japan*, 1921. **24**, 567. 2. Seyewetz and Miodon, *Bull. Soc. Chim.*, 1923, **33**, 449.

ELECTROLYTIC REACTIONS ON POROUS CARBON ANODES—PART II: The Preparation of Chloroben zene from Benzene

Chlorobenzene is now extensively used in industries for the manufacture of phenol, aniline, D.D.T., etc., and as a solvent. The well-known chemical method for the production of chlorobenzene is the chlorination of benzene in the liquid phase. The reaction is exothermal and needs careful control of temperature.

Researches on electrolytic chlorination of benzene have been fairly extensive. The latest is that of Croco and Lowy[1] who obtained with vigorous stirring (350 r.p.m.) a current efficiency of 75 per cent. using graphite anode. In our experiments stirring was eliminated, benzene was made to flow through the pores

of the anode by gravity and recycled through the anode for maximum advantage. The bath was composed of a solution of monochloracetic acid in concentrated hydrochloric acid and could be used continuously for a series of experiments.

Using iodine, ferric chloride, and cyanuric acid as catalysts respectively, current efficiencies of 33 per cent., 68 per cent. and 89 per cent. respectively were obtained at a current density of 0·026 amp. per square cm. at 38° C.

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ELECTROLYTIC REACTIONS ON POROUS CARBON ANODES—PART III: The Preparation of Ethylene Chlorhydrin and Ethylene Glycol from Ethylene

ETHYLENECHLORHYDRIN and ethyleneglycol are largely used as industrial solvents in the drug industry. The methods of preparation are based on the reaction between ethylene and hypochlorous acid formed by passing gaseous chlorine into water or by the action of boric acid on a hypochlorite solution. As regards their preparation by electrochemical methods, only three references could be traced.[1]

It has been found that ethylene on electrolytic oxidation on a porous carbon tube as anode in an electrolytic bath of sodium chloride, produces both chlorhydrin and glycol—the yield of each depending on experimental conditions. For example, working with a solution containing 10 per cent. sodium chloride at a flow rate of ethylene of 57 c.c. per hour per sq. cm. of anode surface, and a current density of 0·023 amp. per sq. cm., the current efficiency calculated on the basis of ethylenechlorhydrin has been found to be 91 per cent. at 1° C. and 1·1 per cent. at 91° C.; and calculated on the basis of glycol has been found under identical conditions to be 5·4 per cent. at 1° C. and 16·5 per cent. at 91° C. The reactions may be represented as follows:—

1. CH_2: $CH_2 + OH^- + Cl^- = CH_2OH \cdot CH_2Cl + 2e$

2. CH_2: $CH_2 + 2\,OH^- = CH_2OHCH_2OH + 2e$.

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ELECTROLYTIC REACTIONS ON POROUS CARBON ANODES,—PART IV: Preparation of Chloral from Alcohol

CHLORAL is now an important intermediate in the manufacture of D.D.T. Chloral alcoholate obtained by the reaction of dry chlorine with dry alcohol is converted into chloral by sulphuric acid. Koidzumi[1] has done some work on the electrolytic preparation of chloral.

In our experiments the bath was composed of a concentrated solution of sodium chloride in a copper vessel which acted as a cathode. As the alcohol was gradually introduced into the anode compartment through the porous carbon anode it reacted according to the equation:—

$$CH_3CH_2OH + 8\,Cl = CCl_3CHO + 5\,HCl$$

The experiments were carried out at 100° C. so that the chloral formed distilled off immediately and was thereby removed from further anodic attack. It was found, that besides chloral and chloral alcoholate, other products like monochloracetic acid, ethyl acetate, monochloroacetaldehyde hydrates and alcoholate were obtained as by-products—the yields depending on experimental conditions.

Working with a saturated solution of sodium chloride maintained at a temperature of 100° C., at a current density of 0·04 amp./sq. cm. and using porous carbon impregnated with 6·5 per cent. by weight of cyanuric acid, the current efficiency calculated on the basis of chloral has been found to be 33·4 per cent.

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NOTE ON THE ESTIMATION OF CHROMIUM IN CHROMITE ORES

CHROMIUM is generally estimated in chromite ores by fusing the chromite with sodium peroxide in a nickel or a porcelain crucible. Ordinarily a nickel crucible can stand 5-6 peroxide fusions while some of the porcelain crucibles could hardly stand two fusions. Added to this, the nickel peroxide formed during fusion requires long boiling before it is completely dissolved in sulphuric acid. The chief constituent that has to be analysed in the chromite ore is the chromium oxide (Cr_2O_3); sometimes iron oxide (Fe_2O_3) is also wanted. Silica is rarely required. In view of the scarcity and high cost of the nickel crucibles, the following simple method has been standardised employing a glass test tube for the peroxide fusion.

Sodium peroxide (1-2 g.) is introduced into a dry stout-walled test tube and finely divided

chromite ore (0·1-0·2 g.) is weighed in a narrow glass tube (4 mm. dia.) and introduced into the test tube taking care that the chromite does not stick to the sides of the test tube. A further quantity of sodium peroxide (1-2 g.) is added to the test tube, and the contents well mixed by gentle rotation of the test tube. After mixing, the contents are covered with a layer of sodium peroxide and gently heated over the flame to melt the peroxide. The peroxide is maintained in the molten condition for 15 minutes with occasional shaking and then the contents allowed to solidify. The hot test tube is introduced into a tall beaker containing a drop of water when the test tube develops cracks. After cooling, the mass is extracted with cold water, boiled to expel dissolved oxygen and acidified with sulphuric acid and the chromate estimated in the usual manner.

The following table gives the results of analysis by the two methods.

	Nickel Crucible Fusion	Test tube Fusion
Sample I	Cr_2O_3 — 44·50 Fe_2O_3 — 40·29	44·54 40·18
Sample II	Cr_2O_3 — 47·75	47·62
Sample III	Cr_2O_3 — 47·.8	47·85

Iron is usually estimated by filtering the ferric hydroxide from the aqueous solution of the fusion mixture. But this method is usually tedious and requires a very thorough washing of the ferric hydroxide. Even after 5-6 washings with hot water, the ferric hydroxide retains a small quantity of sodium chromate. The following simplified method gives very good results and saves a good deal of time. The aqueous solution of the fusion mixture is acidified with sulphuric acid and diluted to 200 c.c. A portion of the solution (50 c.c.) is subjected to reduction in a Jones reductor when the dichromate is reduced to chromium sulphate and the ferric to ferrous sulphate. The reduced solution is titrated against potassium permanganate and the iron contents calculated. The iron values for sample I are also given in the table.

The following are the advantages of the present method over those that are described in the literature.

(1) The use of nickel crucible is avoided.
(2) The separation of ferric hydroxide is altogether eliminated.
(3) The method saves time.
(4) The process of fusion can be watched since it takes place in the glass test tube.

This method cannot be employed when silica has to be estimated in the chromite.

The authors wish to express their thanks to Sir J. C. Ghosh, Kt., D.Sc., F.N.I., for his keen interest in the work.

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EXTRACT OF BROOD LAC AS A SUPPLEMENTAL NUTRIENT FOR THE PRODUCTION OF ANTIBIOTICS

These studies have been inspired by the finding that corn steep liquor[1] speeds up the formation and enhances the yield of penicillin and that organic complexes are essential for stepping up the formation of steptomycin. Waksman[2] has found that an "activity factor" is essential for the formation of the antibiotic; this factor can be synthesised by *Streptomyces griseus* but its addition favours the rapid production of the antibiotic.

Extracts of brood lac, which could easily be made available in abundant quantities, have been found to constitute a rich source not only the complex organic compounds but also a good source of the members of the B-complex. The overall growth-promoting potency of these extracts has been microbiologically assayed by Mande, Mistry and Sreenivasaya.[3] It was, therefore, of interest to determine the overall efficiency of this extract as a fortifying supplement for increasing the rate of formation and the yield of penicillin and streptomycin by their respective micro-organisms.

Experiments on the formation of penicillin were carried with a medium which was composed as follows:—Sucrose 4 gms.; $NaNO_3$ 0·3 gm.; KH_2PO_4 0·1 gm.; $MgSO_4\ 7H_2O$ 0·05 gm.; $FeSO_4$ 0·001 gm.; KCl 0·05 gm.; Distilled water 50 c.c.; pH 6·8.

Aliquots of this medium (2·5 c.c.) were fortified with graded dosages of the brood lac extract (dosages based on the nitrogen content of the extract) and the total volume made up in each case to 5 ml. with distilled water. The medium was sterilised twice at 10 lbs. for 30 minutes and inoculated with a 1 ml. spore suspension in normal saline of *P. notatum* N.C.T.C. 1540 and incubated at 28° C. for seven days. Other experimental details have been described at length in our previous communications.[4] After the period of incubation, the cylinder-plate assay was carried out against a 24-hour old broth culture of *Staph. aureus* N.C.T.C. 2150 and the results are shown in the table below.

The results given in Table I show (1) that the growth of the fungus is proportional to the added amount of the supplemented lac extract; (2) at higher levels of the supplement an earlier sporulation of the fungus is included; (3) At 0·2 and 0·4 MgN levels there is a four-fold increase in the yield of penicillin as compared with the yield obtained with the unsupplemented basal medium; (4) higher concentrations of the supplement tend to lower the yield of penicillin apparently due to a toxic factor which becomes effective at higher levels of the supplement. This toxic effect has been of the supplement. This toxic effect has also been observed by Mande, Mistry and Sreenivasaya in the course of their studies.

The brood lac extract was supplemented to the basal medium used for the production of

TABLE I

Basal medium no supplement	Basal medium +0·2mgN/5 ml.	Basal medium +0·4mgN/5 ml.	Basal medium +0·6mgN/5 ml.	Basal medium +0·8mgN/5 ml.	Basal medium +1·0mgN/5 ml
Total solids per 5 ml. 0,0 ..	4 mg	8 mg	12 mg	16 mg	20 mg
Rate of growth ++ ..	+++	++++	+++++	+++++	+++++
Sporulation 4th day ..	3rd day	3rd day	2nd day	2nd day	2nd day
Initial pH 6·8 ..	6·8	6·8	6·8	6·8	6·8
pH after 7 days of fermentation 6·2–6·4 ..	6·4—6·6	6·2—6·4	6·0—6·2	6·0—6·2	6·0—6·2
Activity against *Staph. aureus* expressed in Oxford units ml. 3·0 ..	11·0	11·0	9·5	9·2	6·2

TABLE II

	Basal medium—no supplement	Basal Medium +0·2mgN	Basal Medium +0·4 mgN	Basal Medium +0·6 mgN	Basal Medium +0·8 mgN
Total solids per ml. .		4 mg /5 ml.	8 mg./5 ml.	12 mg./5 ml.	16 mg./5 ml.
Rate of growth ..	+++	+++	+++	+++	++++
Sporulation ..	5th day	4th day	———	3rd day	———
Initial pH ..	7·0	7·0	7·0	7·0	7·0
pH after 7 days of fermentation	10·2	9·8	9·8	9·8	10·4
Activity against *B. subtilis* expressed in sq. mm. ..	416	416	491	528	616

the Streptomycin from *Actinomyces griseus*. The composition of the basal medium is as follows:—Glucose 1·0 gm.; NaCl 0·5 gm.; Casein hydrolysate 7·32 ml. (80 mg. of total N); K_2HPO_4 0·1 gm.; Distilled water 50 ml.; pH 7·0.

This basal medium was treated with graded doses of the extract (on nitrogen content of the extract). The total volume of the medium was made up to 5 ml. with distilled water.

A uniform suspension of the spores of *Actinomyces griseus* in normal saline (1 ml.) was inoculated into the medium previously sterilised twice at 10 lbs.—30 minutes. After seven days of incubation at 28° C., a "cylinder-plate" assay was carried against *B. subtilis* to determine the activity. The results are tabulated in Table II.

It will be seen from Table II that there is little difference in rate of growth. But the day of sporulation shifts a day earlier in cases which have received higher levels of the supplement. The rise in pH is marked throughout. The increase in antibiotic activity over the unsupplemented control is 50 per cent.

Attempts at a further purification of the brood lac extract, with a view to concentrate the active factor, are under progress.

We wish to thank Sir J. C. Ghosh for his keen interest in the course of these investigations.

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Bangalore,
March 13, 1947.

1. Moyer, A. J. and Coghill, R. D., *Chem. and Eng. News.*, 1944, **22**, 588. 2. Salman A. Waksman. *Proc. Soc. of Exptl. Biol. and Med.*, 1944, **55**, 66 69. 3. Mande, Mistry and Sreenivasaya, *unpublished*. 4. Ramchandra Rao, T. N., Ram Mohan, R. and Sreenivasaya, M., *Jour. Sci. Ind. Res.*, 1945, **4**, 75 76.

A NOTE ON THE OCCURRENCE OF NORITE IN JUBBULPORE

THE author records here the discovery of a new rock norite from Jubbulpore area (C.P.) by him. Norites occur on the north-east side of Jubbulpore Cantt. forming strips of black masses running N.E.-S.W. From their appearance in handspecimen they look like gabbros but their petrological analysis clearly proves beyond doubt their noritic nature.

Mineralogically they contain :—

Plagioclases (Labradorite and Andesine) upto the extent of 40·80 per cent. These mine-

rals occur in polysynthetically twinned crystals with an extinction angle varying from 25° to 36° and 2 V = 86° for andesine and 78° for labradorite. Andesine is optically negative and labradorite positive.

Rhombic Pyroxenes (Hypersthene and Enstatite) upto 34 per cent. These minerals have straight extinction, good cleavage. Hypersthene shows marked pleochroism. The 2 V for Hypersthene = 86° and it is optically negative. Enstatite is optically positive. The pleochroic formula for Hypersthene is: X = reddish; Y = pale yellow; Z = pale green.

Monoclinic Pyroxenes (Diallage mostly) below 20 per cent. with its usual characters.

Other minerals are biotite, magnetite and a few more accessories. Their chemical analysis reveals the following points:—

Chemical Analysis of the Rock

SiO_2 ..	50·30%	MgO ..	8·74%
Al_2O_3 ..	18·32%	CaO ..	9·37%
Fe_2O_3 ..	2·76%	Na_2O ..	1·86%
FeO ..	5·56%	K_2O ..	1·90%
TiO_2 ..	trace	Water ..	1·24%

Megascopically they are more or less coarse-grained granular, hypidiomorphic and black coloured. Sp. gr. varies from 2·93 to 3·1.

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Benares Hindu University, R. C. SINHA.
December 14, 1945.

TRACHYBASALTS FROM THE CUDDUPAH TRAPS (*PRE-CAMBRIAN*)

DURING the course of a detailed investigation of the igneous rocks associated with the Cuddupah sediments, a portion of which has already been published by the author,[1] an interesting variety of rock has been discovered near Royalcheruvu (Ananthapur District) which on examination shows extremely well-developed fluidal texture of microlites of felspar (*vide* Fig. 1). Such a rock with a definite trachytic texture had not been noticed so far from among the basic volcanic rocks of Cuddupah.

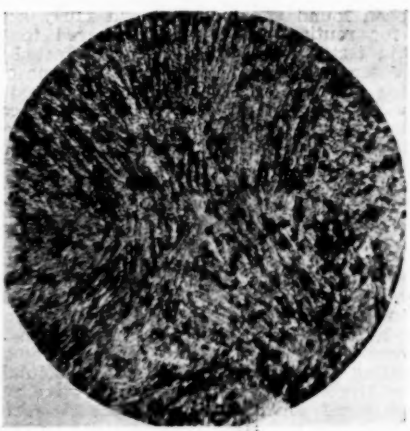

FIG. 1 × 45. Trachybasalt showing fluidal texture.

The sp. gr. of the rock is 2·9, rather much higher than the ordinary trachytes which usually show an average sp. gr. of 2·6. The rock is greenish grey in colour with a typical aphanitic appearance. Under the microscope it shows a colourless glassy groundmass with numerous microlites of felspar arranged in typical trachytic manner. Some of these show straight extinction and are, therefore, oligoclase microlites; while others, which are untwinned are orthoclase microlites. There are numerous colourless granules of augite, olivine and cubes of magnetite. A few corroded microphenocrysts of felspar with numerous inclusions have also been noticed. Though the texture is typically trachytic the rock is termed a trachybasalt on account of its high sp. gr. value and the basic character of the felspar microlites. On comparison, it is found to be almost similar to the mugearites described by Harker[2] from the Skye islands, and the trachybasalts described by W. Cambell Smith[3] from Kenya colony. The rock is being chemically analysed and the details will be published shortly.

Department of Geology,
Central College, M. R. SRINIVASA RAO.
Bangalore,
March 11, 1947.

1. Srinivasa Rao, M. R., "The compo-ite sill of Jutoor, Cuddupah formations" *Mys. Uni. Journl.*, 1945, **6**, 47. 2. Harker, A., *Tertiary Igneous Rocks of Skye*, 1904, 264. 3. Cambell Smith, W., "Trachytes and Phonolites from Kenya Colony." *Q.J.G.S.*, 1931, **87**, 253.

ELASTIC CONSTANTS OF ALUMS AND MIXED ALUMS

THE elastic constants of potassium alum, chromium alum and mixed alums of both of these of varying compositions by weight have been determined by using the wedge method developed in this laboratory.

Suitable single crystals have been grown from solutions and they all belong to the cubic system. 100, 110, and 111 sections of about 1 mm. thick are cut and ground; and frequencies ranging from 1 to 10 megacycles have been employed.

The following values for C_{11}, C_{12}, C_{44} in units of 10^{11} dynes/cm.^{2} are obtained in each case. Densities are determined by the author

No.	Substance	Percentage in gm. of pot. alum.	Density (gm/cm^3)	C_{11}	C_{12}	C_{44}
1	Potassium alum.	100	1·760	2·56	1·07	0·86
2	Mixed alum. ..	86·5	1·772	2·52	1·05	0·81
3	Do. ..	60	1·796	2·47	1·01	0·78
4	Do. ..	54·5	1·802	2·44	1·00	0·78
5	Chromium alum	0	1·845	2·37	0·93	0·77

and compositions of the mixed alums are deduced from the linear law of densities for isomorphic crystals.

In the literature, values of C_{11}, C_{12}, and C_{44} are available from Voigt's[1] work on potassium alum; and in the above units they are respectively 2·43, 1·009, and 0·843, comparing well with the results of the present investigation.

Department of Physics,
Andhra University,
Waltair, R. V. G. SUNDARA RAO.
February 28, 1947.

1. Voigt, W., *Gottinger Nachrichten*, 1918-19 Heft, I. 85.

BLOOD GROUPS OF PUNJABIES AND MALDIVIANS

OPPORTUNITY was afforded during the war to examine the blood groups of 2,500 Punjabies at the I.M.H., Rawalpindi, and of 211 Maldivians at Addu Atoll.

This Atoll is the southernmost of the Maldive group of islands and the inhabitants are Singhalese in origin. A considerable inbreeding has been going on for a few centuries and the total population is less than 2,000. Therefore 211 persons were considered to be fairly representative random sample.

Vincent's technique was followed to determine the groups. The frequency distribution of different groups was as follows:—

	O	A	B	AB	A/B ratio
Punjabies ..	34·8	24·5	33·3	7·4	0·7
Maldivians ..	58·3	17·5	21·8	2·4	0·8

Field Typhus Research Dett., S. L. KALRA.
GHQ. Med. Research Organisation,
Jubbulpore,
February 17, 1947.

TURBIDITY TEMPERATURE OF OILS AS DETERMINED BY BELLIER'S TEST AND ITS SIGNIFICANCE AS AN ANALYTICAL CONSTANT

THE solubility of oils in various solvents is a constant, depending on the nature of the glycerides composing the oil. In the Valenta test, acetic acid is used as a solvent. Fryer and Weston[1] found that a mixture of equal volumes of 92 per cent. ethyl alcohol and pure amyl alcohol can also be satisfactorily employed as a solvent for turbidity value. This turbidity value is the temperature at which the solution of oil in the solvent shows the first signs of turbidity on cooling.

There are two factors which, if not allowed for, entirely destroy the reliability of the estimation of solubility in the solvents. One is free fatty acids which lower the turbidity temperature, increasing the solubility of the oils. The other is moisture, which raises the turbidity temperature, decreasing the solubility. In the Valenta test preliminary operations, *viz.*, standardization of the solvents, preparation of oils, corrections for free acidity, moisture and acetic acid, etc., have, therefore, to be carried out.

In the case of soap and commercial fatty acid analysis the original glycerides are not available and, therefore, Fryer and Weston[2] investigated the turbidity temperatures obtained with the mixed fatty acids themselves with various solvents and proposed acetic acid of 90 per cent. strength as the most suitable solvent for the purpose and standardized as in the test for oils against pure oleic acid. The presence of small amounts of undecomposed glycerides in the mixed fatty acids raises the turbidity temperature considerably; it is, therefore, essential that a complete saponification is obtained before the test is made, and the mixed fatty acids from soap or as obtained commercially, should preferably be resaponified by alcoholic potash. These authors have suggested that in addition to its value in the analysis of soap and of commercial fatty acids, the test may be applied to oil analysis. It has the advantage that no correction for acidity is necessary as in the case of oils. A further advantage offered by this method is that the result is not influenced by the presence of moisture in the oil or in the acid as in the case of the turbidity test with the oil (Valenta test).

The turbidity temperature as determined by Bellier's test is also based on the solubility factor of the mixed fatty acids of the oils in 70 per cent. alcohol under prescribed conditions and is characteristic of a particular oil. The test was subsequently modified by Mansfeld, Alder and Franz and examined by Evers[3] who found the modification satisfactory. Fryer and Weston also confirmed this in their own experience and has described it in their *Technical Handbook of Oils, Fats and Waxes* (Vol. II, p. 140). This modified test has been used by the writer for judging the purity of oils and has been found simple, rapid and fairly accurate for routine analysis as compared to the Valenta test. The results are not affected by the presence of moisture in the oil and no corrections for free acidity, etc., are required as in the Valenta test. Moreover, it can be conveniently used in the analysis of soap and commercial fatty acids and also for determining the percentages of two mixed oils, if the range between the turbidity temperatures of these two oils is fairly wide, *e.g.*, groundnut oil and sesame oil, almond oil and sesame oil, etc. Other workers[4] have also successfully used the same test for determining adulteration of groundnut oil in some edible oils and also suggested its analytical importance. Besides, the turbidity temperatures obtained with fatty acids by the method of Fryer and Weston are different from those for the respective oils, depending on the difference in the solubility of the glycerides of the oil and its fatty acids in the same solvent. If the Bellier's test is employed for the same purpose, the turbidity temperatures obtained with oils and their mixed fatty acids are nearly identical as the

glycerine that is split up from the glyceride has been found to exert no appreciable effect on the turbidity temperature. This is evident from the identical turbidity temperatures of fatty acids and glycerine (as in the case of oil) and prepared fatty acids alone (fatty acids prepared from the respective oils, *vide* Table III). Again, uniformity of solvent, *viz.*, 70 per cent. alcohol, is maintained as regards analysis of oils, soaps and fatty acids. In the Bellier's test 1 c.c. of commercial acids or those split up from soap is boiled with alcoholic potash, treated with acetic acid and the tubidity temperature is then determined. This treatment with potash in the test itself has the advantage that it ensures complete saponification of the unchanged glycerides, if any, present in the soap; and, therefore, separate treatment with potash is not necessary as in the case of Fryer and Weston method for fatty acids and soap analysis as mentioned above.

Turbidity temperatures of some common oils and fatty acids split up from oils have been observed for a number of samples of the same oil. This temperature has been found to be nearly constant for an oil. However, after examining a large number of commercial oils, it has been found that it varies within two degrees for some of the samples of the same oil. But it is more specific than other analytical constants, such as saponification value, iodine value, etc., which have a comparatively wide range. Turbidity temperatures as recorded by other workers differ; but the difference is likely due to variations in the composition of different mixed fatty acids in oils of different climatic regions. The margin of difference, however, is not so great as in the case of other analytical constants.

TABLE I

Turbidity Temperatures and Butyro-Refractometer Readings

Oil	T.T. in °C.	B.R.R. at 40°C.
Almond ..	1— 2	57·0
Olive ..	13—14	55·4
Coconut ..	12—13	35·5
Safflower ..	12—14	66·0
Nigerseed ..	22·5—25	63·0
Rape ..	22	59·5
Cotton-seed ..	21	58·5
Castor ..	— 5·0	69·0
Maize ..	21·0	59·5
Arachis ..	38—38·5	55·5

The turbidity temperature together with B.R. reading enables the chemist to judge fairly easily the purity of the oil. In the case of almond oil which is rather costly, the adulteration with olive, sesame or arachis oil can be readily detected and even ascertained as 5 to 10 per cent. of any of the adulterants raises its turbidity temperature by 6°-15° C.

The turbidity temperatures of oils and the corresponding mixed fatty acids split up from these oils and also turbidity temperatures of mixtures of two oils and the corresponding fatty acids prepared separately from these mixtures are nearly identical; as it has been found that the presence or absence of glycerine in the test has practically no effect on the turbidity temperature, which is, therefore, characteristic of free fatty acids present in the solution.

TABLE II

Oil	T.T.
Almond ..	1—2
,, + 5% Olive ..	6·0
,, + 10% ,, ..	8·0
,, + 5% Sesame ..	6·5
,, + 10% ,, ..	8·5
,, + 5% Arachis ..	11·0
,, + 10% ,, ..	15·0

TABLE III

Oils	T.T. of oils	T.T. of fatty acids
Groundnut ..	38–38·5	38·5
Sesame ..	15–16	16·5
Coconut ..	12–13	13·0
Almond ..	1–2	1·0
Olive ..	13–14	14·0
Groundnut 50% Sesame ,, ..	30·5	30·5
Groundnut 30% Sesame 70% ..	24·5	24·0
Groundnut 50% Coconut ,, ..	30·5	30·5
Groundnut 80% Coconut 20% ..	36·5	36·0
Groundnut 50% Almond ,, ..	30·5	30·0
Groundnut 50% Olive ,, ..	30·0	31·0

When the test is employed for a mixture of two oils the turbidity temperature of the mixture will be predominantly influenced by the oil which has a higher turbidity temperature. This is evident in the case of groundnut oil when it is adulterated with other oils such as almond, olive, sesame, nigerseed, coconut, safflower, etc. A series of experiments were carried out by taking pure samples of the above oils and mixing them with pure groundnut oil in definite percentages and determining the turbidity temperatures of the corresponding mixtures. These results have been tabulated below with the B.R. reading of pure oils.

A chart of the above results, if plotted, enables the analyst to determine the percentage of adulteration with groundnut oil in various oils nearly accurately. The procedure can be conveniently followed in the case of other oils by plotting such charts of turbidity tempera-

TABLE IV

A	B				
Per cent. of Groundnut oil B. R. Reading .. 55·5	Turbidity temperature of the oil mixture containing the percentage of groundnut oil shown in column A and the oil mentioned below to make up the balance				
T.T.	Coconut BR. 35·5	Nigerseed BRR. 63·0	Safflower BRR. 66·0	Almond BR. 57·0	Olive B.R.R. 55·4
Pure oil, 38 —38·5	12—13	22·5—25	12—14	1—2	13—14
Gr. 10%	16·0	26·0	18·5	15·0	17·5
„ 20%	20·0	28·0	22·5	20·0	21·0
„ 30%	24·0	29·5	27·0	25·0	24·0
„ 40%	27·5	31·0	30·0	28·0	27·0
„ 50%	30·5	32·5	32·0	30·5	30·0
„ 60%	32·5	34·0	33·5	32·5	32·0
„ 70%	34·5	35·5	35·0	34·5	34·0
„ 80%	36·5	36·5	36·5	36·0	36·0
„ 90%	37·5	37·5	37·5	37·5	37·5

tures of any two oils mixed in definite proportion.

Department of Chemistry,
M.T.B. College, C. M. DESAI.
Surat,
February 23, 1947.

1. Fryer and Weston, *Analyst*, 1918, **43**, 4-20. 2. —, *Technical Handbook of Oils, Fats and Waxes*, **2**, 302-353. 3 Evers, *Analyst*, 1912, **37**, 487. 4. Hawley, H. *Curr. Sci.*, 1937, 640; Desai, C. M., and Patel, A. H., *Ibid.*, **1945**, **37**, 130; Narayanier, S., *Ibid.*, 1945, 177.

A METHOD OF SEALING TUBES OF FUNGAL CULTURES TO INCREASE THEIR LONGEVITY

MAINTENANCE of fungi on nutrient media involves frequent transfers, as the medium soon loses its water contents and becomes dry, especially under the dry and hot climatic conditions of Delhi. Several attempts were made to modify the standard method so as to check the quick-drying of the nutrient agar medium and thus to reduce the frequency of subculturing. It was realised that if the mouth of the culture tube were closed some other way than by the usual cotton-wool plug so that the hot and dry atmosphere of the room in which the cultures are stored did not affect the agar medium inside the tube it would remain moist for a longer period. A substitute was ultimately found in a combination of cellophane and paraffin wax. The fungi in culture tubes thus sealed have been found to remain viable for at least eight months (Fig. 3), and the transfers made grew true to type. The growth of the fungus in sealed tube was seen to have been checked but when at the end of eight months the seal was replaced by the usual sterilised cotton-wool plug the fungus resumed its growth. In parallel sets of cultures maintained in tubes either plugged with cotton-wool or sealed with cellophane the media had completely dried and had become brittle and membranous (Figs. 1, 2), the fungi in these tubes were no more viable. For these trials the following fungi were used :

FIGS. 1–3. Cultures of *Polystictus hirsutus* (Wulf) Fr. subcultured on 19-3-46 on Potato Dextrose agar; photographed on 19-11-46.

FIG. 1. Culture tube plugged with cotton wool.

FIG 2. Culture tube sealed with cellophane.

FIG. 3. Culture tube sealed with cellophane and paraffin wax.

Macrophomina phaseoli (Moulb.) Ashby, *Penicillium notatum* Westl., *Melonopsichium eleusinis* Mundkur and Thirumalachar, *Saccharomyces cerevisiæ* Hansen, *Trichoderma viride* Pers. ex Fr., *Polystictus hirsutus* (Wulf.) Fr., *Fusarium fructigenum* Fr., *Alternaria solani* (Ell. et Mart.) J. et Gr.

For this method of sealing pieces of cellophane are cut to the required size; they should be big enough to go over the mouth of the culture tube and to cover a part of the wall of the tube. They are sterilized with alcohol and stored in sterilized petri-dishes. For fixing these pieces to the tube a water solution of 15 per cent. gelatine and two per cent. copper sulphate is used. This solution is kept in a covered container like a petri-dish. The required sub-culture is made in the usual way on a standard medium like P.D.A. and the tube is plugged with cotton-wool; when the culture is well-grown in about a week's time the cotton-wool plug is removed under aseptic conditions, the mouth of the tube is immediately dipped for a few seconds in the gelatine solution. The mouth of the tube is then placed vertically on a piece of sterilized cellophane paper; the free ends of the cellophane are then pressed down the sides of the tube; when the gelatine has set a good seal has been formed; the mouth of the tube is then dipped into hot melted paraffin so that the cellophane paper is covered with wax; the whole process of sealing the tube in this way can be performed in fifteen seconds.

Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, New Delhi, B. M. GUPTA.
January 28, 1947.

A CASE OF POLYEMBRYONY IN *POIVREA COCCINEA* DC.

(=*Combretum coccineum* Lamk.)

THE development of the embryo of *Poivrea coccinea* has been found to take place according to the Asterad type. Usually only one embryo is developed in each ovule. In a single case, however, two embryos have been found to be formed (Fig. 1). One of the embryos is developed from the fertilised egg. The other one is near it. Judging from the position it is possible that it is developed from either one of the synergids or from a cell of the nucellus

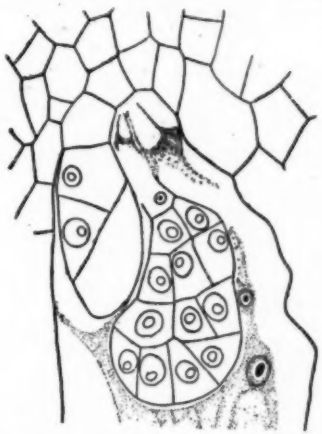

FIG. 1. *Poivrea coccinea*. L. S. of the micropylar part of the embryo-sac with the nucellar cells above it showing two embryos in the embryo-sac, × 215.

abutting on the micropylar end of the embryo-sac. In this plant, however, the synergids are observed to persist until a late stage of the development of the proembryo. The apical parts of the synergids are clearly seen in the preparation (Fig. 1). Hence the extra embryo seems to have been developed from a nucellar cell.

Department of Botany, Andhra University, Waltair, J. VENKATESWARLU.
February 15, 1947.

SYNTHETIC PENICILLIN

THE announcement that American research workers have recently isolated a specimen of synthetic penicillin has led to reports that synthetic penicillin, will very shortly be cheaply and plentifully available. Such reports are, however, based on a misunderstanding of the nature of the synthesis achieved. The work has been done by Dr. Vincent du Vigneaud and his research team at the Cornell University Medical School, New York, and is described in *Science* (Vol. 104, 1946, pp. 431-33). They found that the product of reaction between two decomposition products of penicillin-*d*-penicillamine and 2-benzyl-4-methoxymethelene-5-(4)-oxazolone possessed slight antibacterial activity. Assay showed, however, that the yield of penicillin was less than 0·1 per cent. A similar result was recorded by Oxford workers in 1942; they demonstrated that the activity of the product was due to penicillin by inactivating it with the highly selective enzyme, penicillinase. In view of the very low yield, however, the reaction was not further investigated at Oxford.

Starting with this very impure reaction product, du Vigneaud and his colleagues obtained, by a laborious extraction process, about 6 milligrammes of crystalline synthetic penicillin G. The course of the reaction and purification was followed by replacing some of the ordinary sulphur atoms in the penicillamine by a radioactive sulphur isotope which could be detected by Geiger counters. The work is of considerable theoretical interest and a fine example of skilful chemical research, but it is of no commercial importance because the starting materials themselves are difficult and costly to synthesise, the yield is tiny and the purification process very time-consuming. Difficult though it is, however, the method may be valuable for preparing, for experimental purposes, varieties of penicillin other than those known to be produced by the mould.

—(Courtesy of *Discovery*, 8, No. 2, Feb. 1947.)

REVIEWS

Crop Production and Enviroomeni. By R. O. Whyte. (Faber & Faber, London), 1946. Pp. 372. Price 25*sh*.

The ultimate aim of all botanical research is to so control and direct the behaviour of plants as to get the maximum benefit out of them. Several of the practices followed by farmers and horticulturists are based on developmental physiology although they have been evolved by long experience without an appreciation of the scientific principles involved. The work of the plant physiologists has been concerned with the most detailed possible objective description and interpretation of phenomena occurring in living organisms, and among the attempts to actually control the phenomena by subjecting their progress to the will of man, the discovery of the Russian botanist, Lysenko, might be considered the most important in recent times. This discovery known as 'Vernalization' or pretreatment of activated seed has been exploited with enthusiasm and great expectations all over the world, and considerable amount of literature has appeared on the subject. The present book has brought together "all the available scientific evidence and practical experience in order to show how and when crops react to environment and to indicate how this nature of reaction affects crop yields, distribution and general agronomic behaviour and techniques". A critical review of the earlier investigations which had formed the background for Lysenko's discovery forms part of the book. The earlier enthusiasm for vernalization as such has perhaps cooled down, and India is the only country outside U.S.S.R. that is still taking an acive interest in pretreatment of seeds in various crops. The book should, therefore, be specially welcome to biological workers in India.

The first few chapters of the twenty contained in the book deal with growth and development, the distinction between which must now be familiar to those acquainted with vernalization literature, and the effect of environment like heat, light and darkness on these two phases. It is now recognised that every plant has its own specific requirements of temperature and light in the presence of which it proceeds to reproduction. The work of Gregory and his associates at the Imperial College, London, has led to a better understanding of the biological processes involved in vernalization and it has also established that Lysenko's postulates about the sequence of distinct phases and nonreversibility of the development process are untenable. Every physiologist is familiar with the pioneering work of Garner and Allard on photoperiodic reactions and their division of crops into short-day and long-day plants. Later work in America and Russia is indicating that it is darkness and not the photo-period which activates development in short-day plants, and that it is not the magnitude of the proportion between daily darkness and light but the absolute length of the dark period which is important. Recent researches have also shown that the visible phase or stage of the formation of male and female gametes has environmental requirements of light, and probably also temperature, that differ from those which govern flowering of the plant. Valuable information has also become available on pollen viability in relation to the influence of heat and light.

Three of the chapters in the book deal with the location of response to vernalization and the action of hormones. The critical work at the Imperial College, London, has shown that the seat of response is the embryo and not the endosperm as was believed earlier. All investigations appear to indicate that the responses associated with the photo-periodic reaction are transmitted from one part of a plant to another by means of a substance of a hormonal nature. It is claimed that the hormone or hormones can even pass from one plant to another through a non-living diffusion contact. Even names like florigen and vernalin have been proposed for these hormones but it is not possible to draw any conclusions as they have not yet been identified.

Though investigations on plant physiology and metabolism at different developmental phases or when exposed to controlled environmental factors have not yet reached a stage warranting definite conclusions, the scattered results give an indication of the possible application of the results to the production of optimal yields, either grain or forage, and to the optimal utilization of fertilizers and other cultural measures. Comparing plants raised from vernalized and unvernalized seeds, it is found that while the intensity of photosynthesis is not affected by vernalization, the leaf area, the factor most closely connected with yield, is markedly affected by vernalization. Results of various experiments in cereals are given to show the scope for higher yields by seed treatment. In spite of the large amount of experimentation the practice of vernalization has not been taken up anywhere outside U.S.S.R., not even in Canada and N. America, where it should have been particularly valuable for extending the cultivation in the northern regions. The choice of suitable varieties or breeding special varieties is, however, widely practised and any necessary manipulation of growth or development has been resorted to by adjustments in agronomic practices.

The subject of resistance to adverse environment like cold, heat, drought, exposure to pests and diseases, etc., as related to developmental physiology, is dealt with in a chapter. One interesting phenomenon recorded in several crop plants is the occurrence of maximal infection by fungus diseases and insect pests

at a time when the part attacked has reached a peak in nutritive value or protein content. In most cases breeding and agronomic management offer the only practical means of avoiding damage. .

The chapter on Crop Production and Geographical Distribution deals with the question of general application of experimental results in agricultural and horticultural practices. The most important factors as regards true development of crop plants are the seasonal and daily trends and the length of the daily period of light and darkness. The results of various experiments do suggest that it is possible to find and isolate strains with different critical day-lengths suitable for growing under appropriate conditions. Attention is drawn to the results often obtained by breeders, namely, that the habit of a strain in one environment is not predictable from its mode of growth in another, and that genotypic differences not apparent in one environment may be revealed in another. The close alliance of basic research to practical objectives is exemplified in the location of the new production of sugar-beet seed in U.S.A. making the country independent of the seed supply from Europe.

The review on the gentical aspects of the general problem of developmental physiology is the one that has aroused acute controversy between the Russian school, supporter of phasic development, and the school of formal mendelian genetics. The subject has been very ably dealt with by Hudson and Richens in a recent Agricultural Bureau publication entitled *Soviet Genetics*. The criticism about the inheritance studies of morphological expressions of a physiological condition, for example, earliness and lateness, on the basis of genes is not justifiable for the reason that practical and useful results have come out of such studies in India with special reference to rice. It is doubtful if the behaviour of the time-limited and season-limited rices grown in different parts of India could be satisfactorily explained on the basis of phasic development. It is not clear from the perusal of the publication *Soviet Genetics* if the Russian method of breeding on the basis of length of developmental phase has produced any outstanding results.

The last four chapters of the book which discuss all the results of experiments on the developmental physiology of various representative crops conducted since 1935, contain valuable information of practical importance. The chief crops dealt with are cereals (wheat, oats and barley), sugarcane, grain and fodder legumes, sugar-beet, potatoes, herbage plants and vegetables. There is also included a useful summary in a tabular form of results obtained in Ithaca, New York, on the optimal requirements of heat and light for a whole range of florist crops. The results on tropical and sub-tropical crops are dealt with under rice, wheat, mustard, gram, crotolaria, etc. In concluding the author pays a compliment to Indian workers and says that while the work at the Imperial College, London, may be expected to provide additional knowledge on the fundamental biological processes associated with vernalization, the work in India might provide data to fully assess the practical application of the methods of pre-treatment of crops by temperature or light. It is surprising that the considerable volume of useful work done in India on cotton, with special reference to environment, has escaped the attention of the author.

There is no doubt that the book should prove an invaluable addition to the library of all biological workers. It contains practically all the available information on a subject of research a little over two decades old. In addition to several useful illustrations and charts reproduced from their original publications, there is an exhaustive bibliography given in the end. The author who has already to his credit several useful publications of the Imperial Agricultural Bureau can well be congratulated on this production. There is, however, one defect, if it can be considered a defect, namely, the repetition of information, but this was perhaps unavoidable in the plan he has adopted to deal with the extensive data.

K. R.

Caste in India—Its Nature, Function, and Origins. By J. H. Hutton, C.I.E., M.A., D.SC. (Cambridge University Press), 1946. Pp. 279. Price 18*sh.* net.

When at the present day, Mr. Gandhi has been persistently declaring, in season and out of season, that a caste-less and class-less India alone can afford to exist as an independent political entity, it is bound to be interesting and withal intriguing to note that what seems to me to be the most rational and scientific vindication of the caste-system proceeds from Dr. Hutton, Professor of Social Anthropology in the University of Cambridge, who, in the course of the volume under notice, has undertaken within a comparatively short compass, a masterly analysis of the conditions and circumstances responsible for the origin of the Caste-system and of those responsible for conferment on the said system scientific and sociological validity and sanction. In the brief "Foreword", Dr. Hutton explains in reference to the 5,000-and odd works computed to exist by an American Indologist on the subject of *Caste*, that he has made an endeavour in a comparatively new direction not merely to examine the origins of the caste-system but also to determine its place in the social, and economic structure of Hinduism and Hindusthan.

The work stands divided into *four* Parts. In the first entitled "The Background", which contains *four* chapters, Dr. Hutton has attempted a preliminary clarification of concepts relating to the origin, development, sociological and pragmatic sanctions of Caste-system as it is actually found in Southern India (Chap. 2), Western, Central and Eastern India (Chap. 3) and "Northern India" (Chap. 4). In the "Introductory" chapter, it is pointed out that geographical circumstances have imposed unity on the peoples of this vast sub-continent. At the same time, diverse and different origins of peoples have emphasized variety and multiplicity. The thesis is argued that it is the caste system that has made it possible for harmonization of apparently irreconcilable requirements of geographical unity and variety of origins within a single social system which historically has been demonstrated to have been a stable one.

The *second* Part which also contains *four* chapters is devoted to an exposition and critical discussion of the "Structure", "Strictures", "Sanctions" and the "Functions" of the Caste-system, each topic getting a chapter.

The *third* Part arranged again into *four* chapters, contains an exhaustive examination of the "Origins" of the Caste-system with special reference to traditional accounts of indigenous and intrinsic origins, similar and analogous systems and institutions found elsewhere, and other theories advanced by Indologists and Comparative Sociologists.

The *fourth* Part contains two valuable "appendices", one on "The position of Exterior castes", and the other on "Hinduism in its relation to primitive religions of India" both of which have been reproduced with slight alterations verbal and punctuational in character from Dr. Hutton's *Report on the Census of India* (1931).

The *fifth* Part is made up of an exhaustive "Bibliography", "Glossary" and an "Index" which form the inseparable constituents of paraphernalia of modern publications, edited and planned on lines of scientific and critical investigation.

From the fore-sketched necessarily brief but, fairly exhaustive summary of the main features and contents of Dr. Hutton's work, it must be admitted that the author has been eminently successful in his able attempt to place the much-maligned system of caste in the focus of and proper perspective of sociological and anthropological consciousness, and I would particularly commend the author's judgment that "Indian society has survived a vast number of invasions, revolutions ... conquests ... this is largely due to the caste system ..." (p. 106) to the familiar type or pattern of the ultra-radicals and reformists who have been loudly proclaiming that the ills and troubles confronting the Indian nation directly spring from the accursed caste-system.

In the light of the latest and modernest pieces of legislative enactments such as the Laws relating to validation of *Sagotra*-unions, divorces, etc., Dr. Hutton's volume may be in a sense regarded as an anachronism, but, it would be impossible not to admit that the author has presented the problem of caste in an exceedingly understanding and penetrating manner purely from the standpoint of a disinterested student pursuing the modern scientific and critical methodology.

Dr. Hutton's volume illustrates in an illuminating manner some of the difficulties inseparable from attempts made by foreigners to understand the intricacies of the Sanskrit language. I shall just refer to some. (1) The term *Pravara* (pp. 50-53) printed with amusing and outlandish diacritical marks suggests a meaning quite different from that sanctioned by the context. (2) Likewise, the term *Satapatha* is severely man-handled (p. 258). (3) In the language of the *Gita*, the caste system has been definitely CREATED and brought into being by the Supreme Creator (*"Chatur-varnyam-maya-srishtam"*, Chaps. 4-13). So, it is not quite correct to speak of the system as established by divine ordinance or divine approval. (4) The term *Dharmeswar* is done into "The Righteous one" with interrogation mark on p. 164—and without it on p. 109. The correct rendering would be the Lord or Controller of a spiritual and moral order. These and similar instances have not been covered by the explanation attempted in the "Foreword" of "certain inconsistencies". In the "Foreword", the author has made a confession of his weakness or partiality for the fluctuating use of singular and the plural verbs when the nominative happens to be CASTE. Making the duest allowance for his partiality, I slur over the usage, but, it must be passing strange that a singular verb should have been used when the subject stands in plural (not in reference to the dubious term *caste* however). Thus, you read on p. 95, "Purification and expiation IS followed by ..." But none of these would adversely affect the uniform excellence of Dr. Hutton's work on which he deserves to be unreservedly felicitated.

R. NAGA RAJA SARMA.

HORIZONS OF BIOCHEMICAL THOUGHT

Currents in Biochemical Research. Edited by David E. Green. (Interscience Publishers, Inc., New York), 1946. Pp. 8 + 486. Price $5,00.

The science of biochemistry has proundly directed and fertilised the progress of many other branches of scientific enquiry. It has enriched general biology, chemistry, pharmacology, chemotherapy, medicine, agriculture, nutrition and public health; more recently, biochemical science has invaded the field of genetics, which has resulted in the birth of *Biochemical genetics*, a branch of science which has already shown great promise of a bright and fruitful future. Biochemical science whose principles and techniques are so extensively invoked for the ever-increasing development and specialisation of other branches of scientific research, has been, in consequence, expanding at a terrific rate as can be gathered from even a casual perusal of the scientific literature. The imperative need, therefore, for a survey of the field with a view "to get at the simple essential concepts which are basic to their apreciation" has been generally felt.

Currents in Biochemical Research represents a unique venture in the successful presentation of this survey and in the satisfactory fulfilment of this need. In accomplishing this difficult task, Editor Green has been fortunate in securing the co-operation of the foremost authorities in their respective fields. To quote the prefatory words of the Editor, the volume "represents an attempt by some thirty research workers to describe in as simple language as possible the important developments in their own fields and to speculate a little on the most likely paths of future progress". The most important portion of the volume consists in the exciting glimpses into fascinating horizons of biochemical thought, to which the reader is introduced; not less interesting and valuable are the future trends and applications of biochemical research and experimental technique both of which tend to inspire new and expanding lines of work, and provoke fresh ideas of approach to old problems.

The thirty-one essays which comprise the volume cover a wide field, biochemical genetics, viruses, photosynthesis, plant biochemistry, vitamin research, nutrition, enzymes, intermediary metabolism, heterotropic assimilation of carbon dioxide, Isotope technique, plant and animal hormones, Immunochemistry and Chemotherapy. The two last chapters, one on Social aspects of nutrition and the other on Organisation and support of science in the United States, have a general interest. The volume is unique in its conception and exceptionally brilliant in its execution. It will command a wide circle of readers interested in the pure and applied aspects of biochemical science, and will be received by everyone of them with enthusiasm and gratitude.

Marine Microbiology. By Claude E. ZoBell. (Chronica Botanica Co., Waltham, Mass.; and Macmillan & Co., Ltd., Calcutta), 1946. Pp. xv + 240. Price $5.00.

Micro-organisms play a fundamental and vital role in determining the marine environment; they are the dynamic agents which are intimately associated with the cycles of carbon, nitrogen, phosphorus and sulphur. They actively participate in the geological transformations and in the formation of deposits at the bottoms of the seas. In addition, their biochemical activities have a practical bearing on the fouling of the bottoms of ships and on the corrosion of iron and other metals. Exclusive types of micro-organisms are to be found in the sea by virtue of the fact that it represents a specialised type of environment with a high salinity. These marine organisms may, therefore, be expected to exhibit exceptionally distinctive biochemical functions yet undiscovered; they offer to the biochemist, in consequence, an unexplored and virgin field of research.

Marine micro-organisms have been traced to be directly or indirectly responsible for the formation of gases in the sediments of seas, for the conversion of organic matter into petroleum or proto-petroleum and for the deposition of sulphur. The gypsum type of sulphur deposits are believed to have resulted from the microbiological reduction of calcium sulphate associated with marine sediments. The author puts forth a significant suggestion that "Calcium sulphate is being reduced to sulphur at the expense of the buried organic matter which surves as a source of energy for microbial action." Continuing he adds, "Although conclusive proof is still lacking, it is generally believed by geologists and microbiologists that anaerobic bacteria are responsible for sulfur deposits of the gypsum type. Some of these sulfur deposits in Louisiana and Texas are a hundred or more feet thick. Unique sulfate-reducing bacteria, which appear to be indigenous species, have been isolated from sulfur-limestone-anhydrite formations from a depth of 1,550 feet. Hunt attributed the origin of the sulfur deposits of Sicily to the bacterial reduction of sulfates in ancient shallow marine seas resembling present conditions in the Black Sea."

More recently, deposits of sulphur have been discovered in the coastal areas bordering the Bay of Bengal; these deposits which are confined to the first three feet from the surface have been shown to be due to the action of bacteria which function in a salinity of 10-12 per cent. The subject of marine microbiology is thus one of great practical interest and also one of great theoretical significance.

The author has rendered a great service to the science of marine microbiology by presenting to all the interested investigators a comprehensive, logically arranged and well-documented account of the present status of the problems pertaining to marine microbiology. This volume will remain for a considerable time to come not only an illuminating compendium of reference but also a source of inspiration to all those interested in the development of this fascinating branch of microbiology.

Antibiotics—Parts I and II. By Werner W. Duemling and others. Edited by Roy Waldo Miner. (*Annals of the New York Academy of Sciences, New York*, Vol. 48), 1946. Pp. 31-218.

The New York Academy of Sciences has recently been publishing in its *Annals* a series of valuable records of Symposia held under its auspices, on subjects of topical interest and scientific value. These records contain critical reviews of thoughtfully selected subjects, indicate future lines of development and focus the attention of interested investigators on problems which await solution. The participants in the Symposium on Antibiotics are scientific celebrities in their respective fields and, therefore, entitled to speak with authority on the aspects of the subject which they have chosen to expound.

The present number of the *Annals* on Antibiotics is presented in two parts:—(1) Microbiological and (2) Pharmacological. S. A. Waksman has spoken of the contributions of the microbiologist in discovering and developing antibiotic substances. The history of the development of penicillin production is closely associated with the wartime endeavour to produce regardless of cost an effective antibiotic for controlling certain important diseases of man. It was fortunate that penicillin production was undertaken as one of the wartime projects; research on antibiotics was generously financed and the industry was liberally subsidised. What was the result?

To quote Waksman, "The yield of penicillin in the medium, as a result of the growth of the fungus *Penicillium notatum*, was increased from 2-4 Oxford units per milliliter to 200 and 1,000 units per milliliter. New and very active strains of the penicillin-producing fungi were isolated. Finally, the deep or submerged method for the production of penicillin on a large practical scale was developed. Penicillin was isolated, crystallised, and its chemical nature determined. This remarkable development in the production of penicillin has, finally, led to a rapid rise in the use, on a scale never dreamed of even three or four years ago."

Vigorous search for other antibiotics particularly specific towards gram-negative pathogens led to the development of streptomycin.

Penicillin production became an economic reality thanks to the development of improved

penicillin-producing molds. This aspect of the problem has been presented by Kenneth B. Raper of the Northern Research Laboratory, Illinois. Biochemical aspects of penicillin-producing moulds have been discussed by M. J. Johnson of the University of Wisconsin; a comparative study of the metabolic changes accompanying the tray and tank fermentations, has been made. An article on the production of antibiotic substances by actinomycetes has been contributed by S. A. Waksman himself who is responsible for discovering streptomycin.

The second part of the volume is devoted to a discussion of the pharmacological aspects of antibiotics. Those interested in antibiotics will find in this volume a clear and authoritative exposition of the various aspects of the problem of antibiotics.

Amino Acid Analysis of Proteins. By William H. Stein and others. Edited by Roy Waldo Miner. (*Annals of the New York Academy of Sciences, New York,* Vol. 47), 1946. Pp. 57-240.

Progress in any branch of science is often arrested on an account of certain difficulties inherent to the subject and remains at a stage of disheartening stagnation until a new method of approach is discovered or a new experimental tool of research is forged. Advances in the chemistry of proteins have for some time been rather slow but during the last few years, the analytical approach to the study of proteins has been perfected with a precision which is truly astonishing.

The present number of the *Annals* represents an invaluable contribution to the subject of amino acid analysis of proteins; these methods of analysis, applicable as they have been shown to be to micro-quantities of proteins, have already played a fundamental part in giving us an accurate and complete picture of the amino acid make up of many important groups of proteins. Of particular interest and of essential importance are the two methods of isotope dilution and the more simple but equally accurate and highly specific microbiological method of estimating amino acids.

The advantages of the microbiological methods are beautifully summarised by Hans T. Clarke in the concluding portion of the volume. "Their specificity is high, they are applicable to fantastically small amounts, and their precision is astonishingly great, particularly in view of the uncertainty which always attaches to procedures involving living systems. Although it seems unlikely that they will soon be placed upon a theoretical basis, a brilliant future can safely be predicted for these methods."

Referring to the isotope dilution method, the same author says, "The isotope dilution method, which, theoretically, should yield results of particular value as absolute standards of reference for testing the validity of other analytical procedures, can at present be carried out only in the few laboratories in which a mass spectrometer is operated. If isotope analytical services, available to any research worker, are organised, the isotope dilution methods will become more generally useful."

Those interested in the composition and empirical formulæ of proteins will find the article on "Amino acid composition of simple proteins" extremely illuminating. Thanks to the accurate methods of analysis; it has been possible to determine the amino acid made up of a number of crystalline, homogeneous and integrally pure proteins, *e.g.*, lactoglobulin and insulin and arrive at an empirical formulæ in terms of its amino acid residues. This represents a fundamentally important advance, which has been rendered possible through the analytical approach.

The volume which is well documented with all important references to literature, will be warmly welcomed and widely read by every one interested in the advancement of protein chemistry.

DECENTRALISATION OF INDUSTRIES AND PREVENTION OF WARS

ADDRESSING the scientific workers of the Indian Institute of Science, Acharya J. B. Kripalani, President, Indian National Congress, invited the attention of the audience, to the misuse of the discoveries and inventions of science by political adventurers and dictators, who lacked a moral and humanitarian background. Knowledge is power and the possession of power without the restraining capacity to regulate its use in a moral and discriminating way will only lead to terribly disastrous consequences. There was a period when we might have been able to eliminate wars. The nineteenth century idealists dreamt that such a period was near at hand. But scientific research helped to perfect instruments of destruction and rendered warfare far more terrible and destructive. Scientists could not shirk their responsibility in this matter.

Proceeding, Acharya Kripalani declared, "But science has come to stay; we have to face it and its consequences." He asked, "Can not science so devise means and methods that industries which are so heavily centralised, are dcentralised?" If industries are decentralised, wars will, at least not be mechanised to the extent they are. Scientists can help to decentrlise industries and introduce into the villages specially designed small machines powered by flexible elctric power, and thus contribute to an eradication of most of the evils flowing from centralisation. These small machines can only make what they are intended to and would not lend themselves to be converted ovrnight for the manufacture of the modern weapons of war.

"My appeal to you as scientists is this. Let us make the world a simpler place to live in. Please forget that science should conquer Nature. Nature is a terrible force and it will have its own revenge. Let your aim be to co-operate with, and not conquer Nature. Work 'with' nature. Fabricate small machines which the villager and his family can work at home with electric power and thereby help to decentralise industries."

SCIENCE NOTES AND NEWS

ANTHROPOLOGICAL SURVEY OF INDIA—5-YEAR DEVELOPMENT SCHEME

A scheme for the development of the Anthropological Survey of India was approved by the Standing Finance Committee which met in New Delhi recently under the Chairmanship of the Hon'ble Mr. Liaquat Ali Khan, Finance Member.

The five-year scheme for the organisation and development of the Anthropological Survey of India was prepared at the request of the Government of India by Dr. B. S. Guha, now Director of Anthropological Survey of India, and Col. R. B. Seymour Sewell, of Cambridge University, and lately Director of the Zoological Survey of India. It was accepted in principle by the Government of India last year.

The scheme includes the establishment of a Bureau of Anthropology. The greatest importance of the lines of work to be adopted by the Bureau lies in the effect that the study of Anthropology and the dissemination of a knowledge of the various races and tribes that form the population of India can have on the unifying and gradual welding of the variegated and diverse components into a unified whole. Such an effect, it is pointed out, has already been fully exemplified by the result achieved in the U.S.S.R., where a conglomeration of tribes and races of diverse languages, origin and customs has been welded together into a single unified nation.

The impending changes in the social and administrative services in India will, it is also considered, require expert guidance from a properly developed Anthropological Survey Department, if India is to assimilate about 25 million of the aboriginal and tribal people in a healthy manner into her general system.

The Government of India have already set up a nucleus of the Anthropological Survey of India and an expenditure of Rs. 1,37,730 was provided to meet expenditure during 1946-47. During 1947-48, the second year of the plan, expenditure is estimated to be Rs. 3,62,000. During the years 1948-49 to 1950-51, an expenditure of about Rs. 10 lakhs is estimated. It is proposed to shift the Anthropological Survey of India, which is now situated in Benares, to the Indian Museum at Calcutta where it has been possible to obtain some additional accommodation for it.

URANIUM UNIT OF THE GEOLOGICAL SURVEY

A plan with regard to the uranium and thorium deposits discovered in India will be worked out by the Atomic Research Committee and a Uranium Unit under the Geological Survey of India. The former organisation has already been formed under the chairmanship of Prof. H. J. Bhabha, while the latter is under contemplation and will be in charge of Dr. M. S. Krishnan, when formed.

So far as British India is concerned, the export of uranium, monazite and thorium is at present controlled under the Commerce Department's Export Control Notifications which will continue in force upto March 25, 1946. He indicated also that steps to prevent foreign exploitation of these deposits, including legislative measures if necessary, were under consideration.

There have been small occasional finds of specimens of uranium-bearing minerals from the Abraki Pahar Mica Mines and from Pichhli in the Gaya District, from Sungri in Singhbhum District, from the Sankara and Kodandarama Mica Mines, and from Tummalatalupur in the Nellore District, from near Vaiyampatti in the Trichinopoly District, from Yedur in Mysore, from Thadagay Hill in Travancore and from Bisundni in Ajmer-Merwara.

Monazite, one of the thorium-bearing minerals, occur in the Beach Sands in Travancore State and in the coastal areas of the Madras Presidency and Orissa.

CORRESPONDENCE WITH GERMANY

Indian scientists will be gratified to learn that steps have been taken by the Government of India to permit resumption of commercial, financial and other correspondence with persons and firms in Germany subject to the condition that such correspondence is conducted through unregistered letters up to 1 oz. in weight and non-illustrated postcards. Unregistered packets containing newspapers, magazines and periodicals up to 1 lb. in weight may be sent to the British Zone and the British Sector of Berlin only.

TWO UNITED NATIONS SCHOLARSHIPS FOR INDIAN STUDENTS

The Purdue University, Lafayette, U.S.A., has offered to Indian students two United Nations Scholarships each of the value of 130 dollars per term tenable at the University for study in Science, Engineering, Agriculture, Pharmacy and Education for the term beginning in September 1947.

The scholarships will be granted for one term in the first instance but can be extended a term at a time till the completion of the course provided the scholars make satisfactory progress. Candidates must be graduates of Indian Universities and should be able to supplement the scholarship from their own funds in order to meet the high cost of University education in the U.S.A. They should be prepared to spend about 2,500 dollars from their own pockets.

The Government of India have invited Universities and other Educational Institutions of similar rank to recommend names of suitable students. The final selection will be made by the authorities of the Purdue University.

GOVERNING BODY FOR DELHI POLYTECHNIC

With a view to developing the Delhi Polytechnic into a first class Technological Institution, a Governing Body has been set up under the Chairmanship of Mr. S. Lall, Secretary to the Government of India, Department of Labour. Besides the local industrial and other interests, the Delhi University and the local centre of the Institution of Engineers (India) are also represented on this Body, which will perform both advisory and governing functions. An officer of the Education Department will act as Secretary to the Governing Body.

THE ENTOMOLOGICAL SOCIETY OF INDIA

At the 9th Annual Meeting of the Entomological Society of India, held on 6th January 1947 at Delhi, Dr. K. B. Lal and Dr. K. D. Baweja were eletced President and Secretary respectively.

SIX NATIONAL LABORATORIES

An expenditure of nearly 90 lakhs of rupees for the erection and equipment of the six National Laboratories for Physical, Chemical, Metallurgical, Fuel, Glass and Road Research for the year 1947-48 was approved by the Governing Body of the Council of Scientific and Industrial Research, India, on the 9th February 1947.

GRANT FOR THE RAMAN RESEARCH INSTITUTE

The Governing Body of the Council of Scientific and Industrial Research, India, decided that subject to funds being obtained from the Central Government, a capital grant of Rs. 3 lakhs should be made to the Raman Research Institute of the Indian Academy of Sciences, Bangalore.

HONOURS AND AWARDS

Prof. M. N. Saha has been elected a member of the Astronomical Society, America, and Sir S. S. Bhatnagar has been awarded the Sir C. R. Reddy National Prize in Chemistry.

EXHIBITION OF INDIAN PATENTS

The Exhibition, which has been organised in memory of the late Jamshedjee Tata, is intended to stimulate Indian talent and enterprise to develop the resources of the country. It is proposed to have in the Museum a permanent section for Patents, which may ultimately develop into a Patent Museum.

In his inaugural address, Dewan Bahadur K. Rama Pai, Controller of Patents and Designs, stressed the usefulness of the Exhibition in providing an incentive to inventors and patentees for giving practical effect to many of their ideas. He regretted that Indian inventors were not aware of the proper channel through which their inventions could be adopted for industrial purposes. It was a sad fact, he said, that while 90 per cent. of the applications for patents filed in India during 1946 came from aliens, only 10 per cent. were from Indians. It was, therefore, necessary, he maintained, that the Patent System should receive greater attention in all responsible quarters in the country.

Warning that industrialists should not be hasty when judging the value of the inventions exhibited, Mr. Pai narrated the episode of Alexander Graham Bell (with whose birthday the inauguration of the present Exhibition coincided) at the Philadelphia Exhibition where his invention of the telephone went very nearly unnoticed until the Emperor of Brazil recognized him and appreciated his 'talking box'. He also related Bell's adventures with Mark Twain who refused to invest a small amount in telephone stock and thus lost a fortune. Even the Patent Office, Mr. Pai continued, was sometimes not able to estimate the possibilities of new inventions. While the 1921 Annual Report of the Patent Office had only a sceptical reference to the invention of a pocket *charka*, he had seen in the present day very efficient *charkas* which could be clipped on to the vest pocket like a fountain pen.

Finally, he expressed the hope that the Exhibition would direct the attention of all concerned to the importance of utilizing the Indian Patent System, which has been in existence for more than 90 years, to the best advantage of this country.

INDIAN PHYTOPATHOLOGICAL SOCIETY

The Mycologists and Plant Pathologists who met at the Indian Agricultural Research Institute, New Delhi, at 5 p.m. on 28th February 1947, resolved to establish a Society to be known as the Indian Phytopathological Society, membership of which is open to all persons and concerns interested in the study of fungi, bacteria, viruses and their useful (industrial fermentations, food yeast, penicillin) and harmful (plant and animal diseases) aspects. The Constitution and Byelaws that had been drawn up, were approved. Those interested can join as Patrons paying Rs. 1,000 (=$350 or £ 75), or as Life Members paying Rs. 120 (= $42 or £ 9), or as Ordinary Members paying Rs. 10 (= $3·50 or 15 shillings) per annum. Both the Life Members and Ordinary Members are required to pay an admission fee of Rs. 10, Patrons and Foreign Members being exempt. A Committee consisting of Mr. J. F. Dastur, Chairman, Drs. B. N. Uppal, S. R. Bose, A. Sattar, with Dr. B. B. Mundkur as Convener to found a Journal, was formed and Dr. B. B. Mundkur was elected Secretary-Treasurer for the year 1947. It was also resolved to designate the members joining before January 10, 1948, as Charter Members. A cordial invitation is extended to all persons and concerns in India and abroad to join the Society and make it a success.

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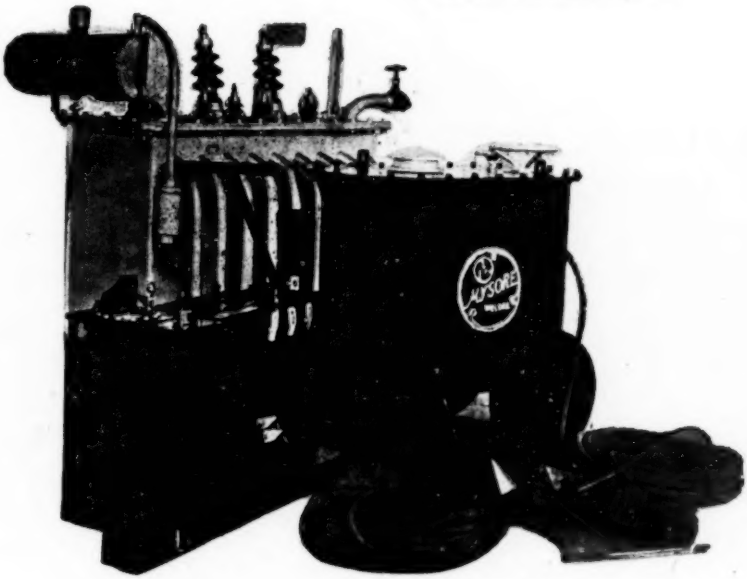
MYSORE

TRANSFORMERS
WELDERS
LEAD_BURNERS



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Beakers	100	250	500	1000	2000 c.c.
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English	2/7	2/11	4/6	5/14	11/14 each

Bottles Reagent flat stopper	4	8	16	32	64	oz.
Indian—Narrow mouth	10/14	14/4	18/8	30	82	per doz.
English ,,	18/14	25/8	35/4	60	192	,,

(*N.B.*—Wide mouth 25% extra ; Extra Wide mouth 75% extra)

Buretttes with stopcock—English 25 c.c. Rs. 11/8 ; 50 c.c. Rs. 13/8 ;
100 c.c. Rs. 16/8 ; Schellback 50 c.c. Rs. 17/8 ; 100 c.c. Rs. 19/8

Butryometers tube—English 8 to 9% as available Rs. 8/12

Desiccator with zinc plate	4″	5″	6″	8″	10″
Indian	8/15	10/6	14/8	39	
English			30	55	84

Dessicator Vacuum—English 8″ Rs. 104

Distilling Apparatus Copper— Capacity	1	2	4	10	20	Gallon
	Rs. 80	104	190	350	550	

Distilling Flask	250	500	1000	2000	3000	5000 c.c.
Indian	3/12	4/7	6/8	10/12		
English	7/15	9/8	14/8	19/8	26	32

Flask Capacity	250 c.c.	500 c.c.	1000 c.c.	2000 c.c.	3000 c.c.	5000 c.c.	10000
Indian	1/2	1/10	2/15	5	10/12	18/8	
English	2/10	4/8	5/14	9/8	14/8	23	38/8

Measuring Cylinder	100 c.c	250 c.c.	500 c.c.	1000 c.c.	2000 c.c.	
Indian	2/6	3/4	5/8	9/8		Each
English	5	7/6	10/15	15/8	26/8	Each

Measuring Flasks Stoppered	50 or 100 c c.	250 c.c.	500 c.c.	1000 c.c.	2000 c.c.
Indian		2/3	2/14	4/6	5/13
English		5/14	7/6	11/8	19/8 24/8

Measure Glass—English 4 oz. 8 oz. 16 oz. Rs. 3/10 ; 4/12 5/12 respectively
20 oz. 7/8 ; 32 oz. 12/8 each.

	1c.c.	2 c.c.	5 c.c.	10 c.c.	25 c.c.	50 c.c.
Pipettes Volumetric Sup. Indian	-/8/-	-/8/-	-/10/-	-/14/-	1/2	1/8
English	1	1/10	1/11	1/15	3/2	4/15
Graduated Sup. Indian	1	1/6	2	2/3	2/8	in 1/10
English	5/4	5/8	6	6/8	7/8	

Separating Funnels English 100 c.c. 12/8 : 250 c.c. 14/12 ; 500 c.c. 21/8 ;
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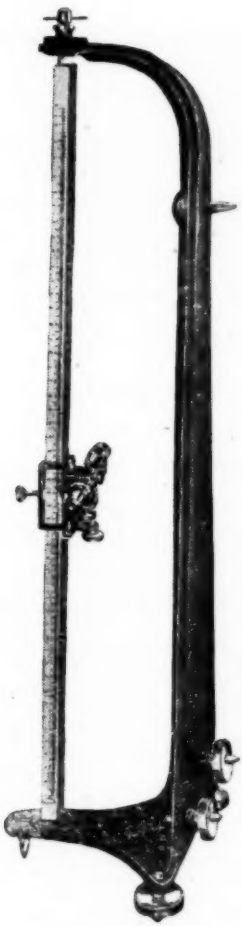
PRECISION CATHETOMETERS

No. 10400



No. 10395

CATHETOMETER
(Simple Pattern)
No. 10400

Designed to provide an accurate instrument at a moderate price. It is lighter in construction and can be used in the vertical position only. The scale is engraved on the vertical rod of 1 cross-section. A vernier reading accurate to 0·05 mm. is attached to the telescope carriage, which moves smoothly along the scale. The telescope is provided with a draw tube for focussing, and is fixed with its axis perpendicular to the scale. The bed is strong and is provided with levelling screws for keeping the scale vertical.

Specification, simple pattern of range
50 cm.
Price: Rs. 250
100 cm.
Rs. 350

NEW PRECISION CATHETOMETER
No. 10395

Indispensable for every college laboratory and useful for measurement of distances between two points which are not accessible. It consists of a telescope with a 7" objective moveable vertically along a scale in mm. with a vernier attachment which can read accurate to ·05 mm. The telescope is adjusted horizontal by a spirit level, and levelling screws are provided in the base of the instrument for adjustment of the scale in the exact vertical position. Rack and pinion is invariably attached to the telescope.

Specification 50 cm.
Price: Rs. 500
100 cm.
Rs. 750

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